The FOUNDRY

Volume 51
Number 11

Published
Semimonthly

CLEVELAND, OHIO, JUNE 1, 1923

Heat Treat to Remove Strains

Large Turbine Frames and Other Castings of a Similar Character Are Heat Treated in a Special Electrically Heated Oven in Which the Casting is Raised To Approximately 700 Degrees Fahr.

BY PAT DWYER

UTILIZATION of electric current for heating various types of furnaces has reached a high point of development in the United States. This condition is attributable to many causes, but probably the greatest single factor lay in the invention of the nickel-chromium alloys consisting of nickel with a chromium content up to 20 per cent patented for use in electrical heating by A. L. Marsh in 1906.

At first glance the use of electrical energy for industrial heating has nothing to commend it. The prime mover seldom has more than 15 per cent thermal efficiency and this in addition to the unavoidable transmission losses and furnace losses reduces the actual available efficiency to anywhere from 9 to 12 per cent. However, a little study and careful comparison of various types of combustion furnaces will indicate that the use of electric current for industrial heating furnaces is not so extravagant as a hurried examination would lead one

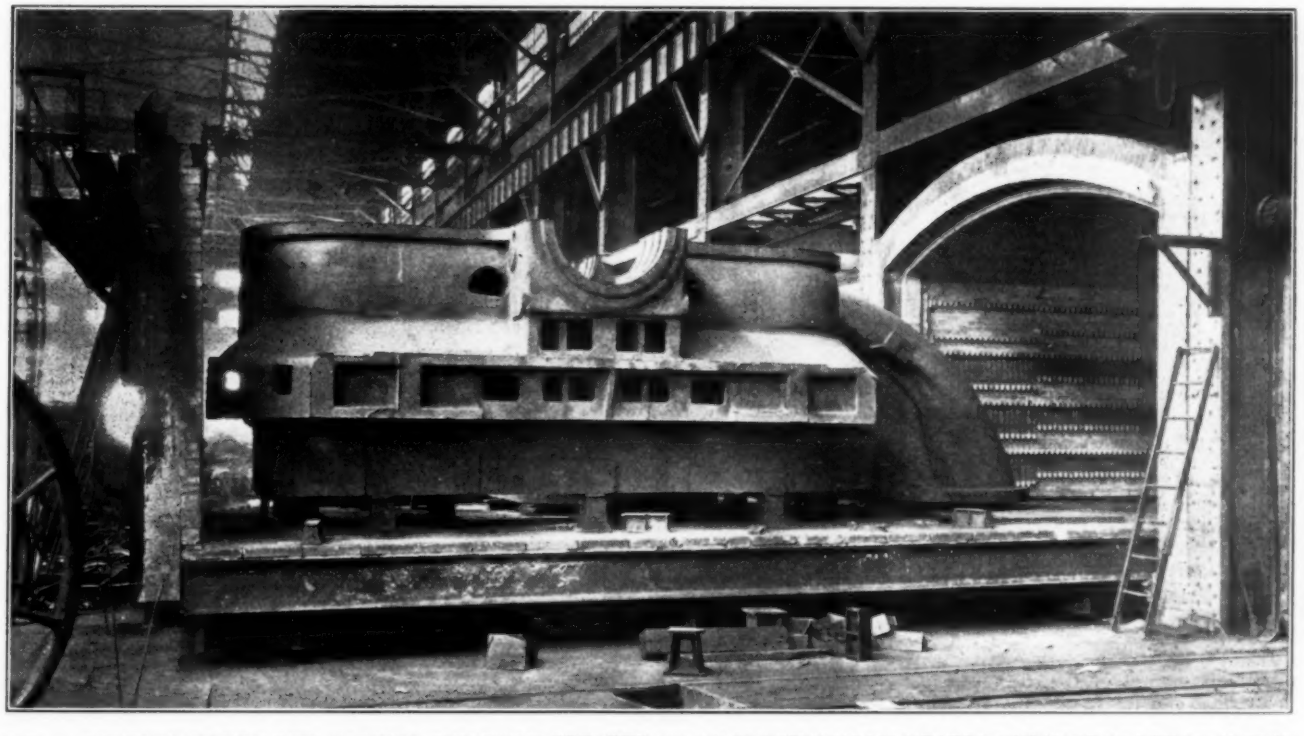


FIG. 1—TURBINE HOODS AND CASINGS ARE HEAT TREATED IN AN ELECTRICALLY HEATED FURNACE 27 FEET 7 INCHES LONG, 15 FEET 10 INCHES WIDE, 8 FEET 7 INCHES HIGH WITH A MAXIMUM OPERATING TEMPERATURE OF 1000 DEGREES FAHR.

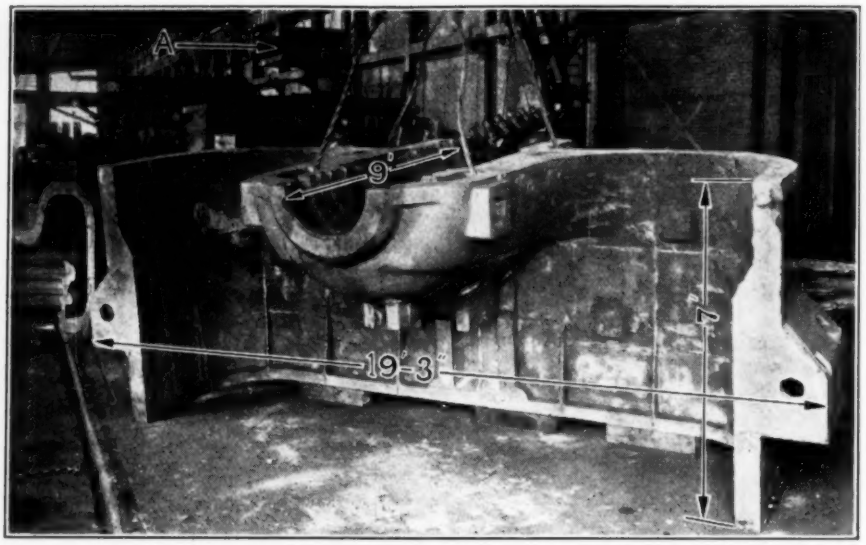


FIG. 2—INSIDE FACE OF TURBINE EXHAUST HOOD IN WHICH THE CONTRACTION IS OVER 2 INCHES IN TOTAL LENGTH

to infer. Many well designed and properly operated combustion furnaces will present a thermal efficiency of 60 per cent, and in a few instances, perhaps a little better; but a far greater number, if carefully tested would show a thermal efficiency rating of between 8 and 15 per cent.

Thermal efficiency probably was given the least consideration of any of the factors involved in the evolution of electrical heating. Convenience, cleanliness, portability, simple and automatic temperature control and furnace atmosphere, uniformity and the results depending on these features were the controlling factors in the minds of those interested in the process. Advocates of the electric furnace claim that in spite of a slightly higher cost of heating element, the ultimate cost is lower than that of heat derived from direct combustion owing to the lower percentage of spoiled work and also to the saving effected in direct attendant labor cost.

Did Pioneer Work

The General Electric Co., did a considerable amount of pioneer work in developing nickel-chromium resistors. Finally it evolved a commercial design, undertook an extensive advertising campaign, sold the equipment to furnace builders and co-operated with them in erection and installation. In proof of the fact that it has faith in its own product, the company built ovens and furnaces of various types at its several plants, including the large annealing oven shown in the accompanying illustration Fig. 1. This oven is in the heavy iron foundry of the company's plant at Schenectady, N. Y., a plant which when operating at capacity employs 20,000 people.

The entrance to the heat treating furnace, the arrangement of the heating element on the side wall, the track and one of the castings to be treated, are shown in Fig. 1. The heating chamber is 15 feet 10 inches wide, 27 feet 7 inches long and 8 feet 7 inches high. The maximum operating temperature is 1000 degrees Fahr. It has a capacity of 620 kilowatts when operating at 550 volts, 3-phase alternating current. A long ribbon of nichrome or chromel is suspended from alundum plugs imbedded in the fire brick of the furnace walls or resting on nickel-chromium supports placed in the walls. The furnace wall is made up of an inner lining of heat insulating brick laid up against a sheet steel casing. The molded alundum ribbon support insulators and spacers are laid in the refractory brick lining. A spacing block is laid between the insulators of adjacent windings. The insulators, spacers and spacing blocks are fitted at the back into a steel channel in the form of a ring made up of a number of sectors tied together by bolted clamps. An opening is provided in the spacing block for the pyrometer tube, with similar opening for the ribbon pyrometer tube in the support insulator.

The car on which the casing is carried into and out of the heat treating furnace is protected on top by a single brick lining and the door, permanently attached to the end of the car, also is provided with a brick lining designed to fit closely in a corresponding recess in the end walls of the furnace. The car frame is made up of strongly braced steel channels and is mounted on three pairs of wheels running in ball bearing journals. One pair of wheels is attached close to each end of the car and the third pair supports the center.

Temperature Control

Cast iron stools, 12 inches high, support the casting on the car at a sufficient height to permit free circulation of the heat. Where the lower face of the casting departs from a straight line, lower stools and wedges are employed to support the weight. Great care is exercised in blocking the casting accurately on the car to prevent it from warping out of shape during the heating process. In practice the casting is brought up to 700 degrees Fahr., in about 3 hours. It is held at that temperature for about 5 hours, then the current is shut off and the furnace is allowed to cool gradually for about 10 hours. At the expiration of

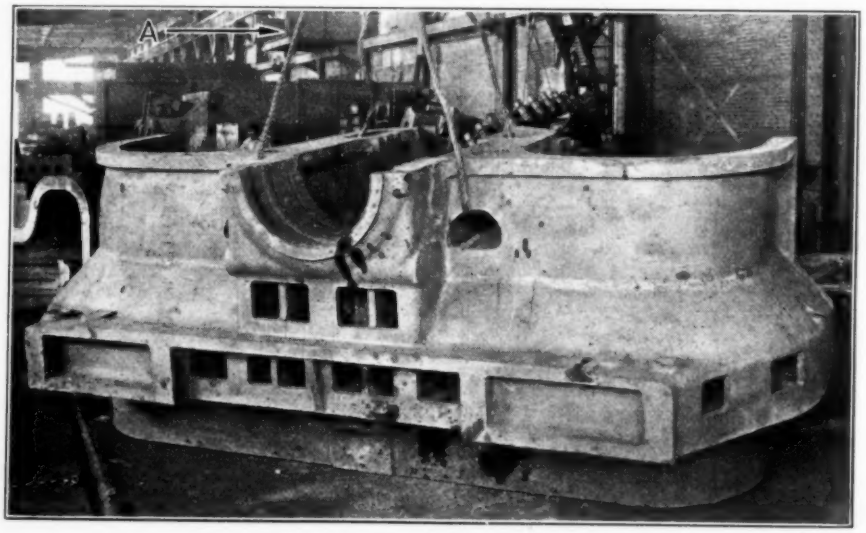


FIG. 3—OUTSIDE FACE OF THE SAME CASTING SHOWN IN FIG. 2

that time the casting has dropped in temperature to between 200 and 300 degress Fahr., and is removed from the furnace and prepared for shipment to the machine shop. The crane is employed to pull the car back and forth through the medium of a long chain attached to the ends and running in a narrow channel below the floor and between the rails.

The casting from the turbine exhaust hood shown in Figs. 1, 2 and 3 and other castings of a somewhat similar character, present interesting problems for the foundryman during the cooling process and while still in the mold. Although the greatest care is observed in making the mold and stripping the casting, care based on a high degree of skill and long experience, uneven, internal strains are developed, due to contraction, varying metal thickness and resistance offered by the cores. For example, by referring to the overall dimensions on the casting shown in Fig. 2, 19 feet 3 inches in length, 7 feet high and 9 feet wide and allowing the standard contraction of ⅛-inch to the foot, it is apparent that the casting is 2½ inches shorter, ⅞-inch lower and 1⅛-inch narrower than the pattern. The part of the mold forming the interior of the casting offers a certain amount of resistance to the contracting metal and in that manner internal strains are set up in the casting. Upon reheating the casting and then allowing it to cool under conditions where no resistance is offered, these strains practically are eliminated.

The immense plant of the General Electric Co. at Schenectady is laid out somewhat after the style of a one-street town in which all the shops face each other across the width of one long straight main street. The analogy further is carried out by the fact that the different departments are known and referred to by numbers instead of by title. Thus the nonferrous foundry, the steel foundry, the light and medium weight gray iron foundry situated at various points along the main street are listed under appropriate individual numbers depending on the location. The numbers begin at one end of the street where the general offices are located and as a result the heavy work gray iron foundry situated about a mile distant is known as 95.

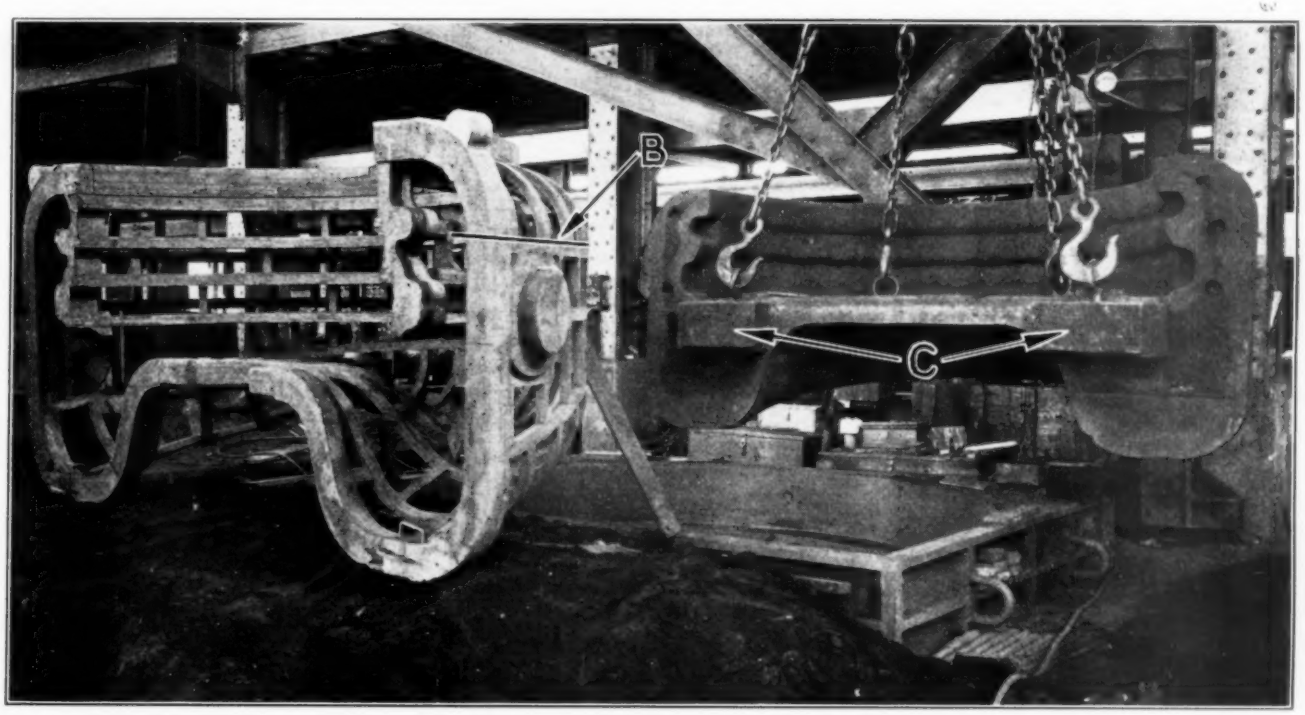


FIG. 4—SKELETON PATTERN FORMS BOTH INSIDE AND OUTSIDE OF THE MOLD—THE BODY OF SAND FORMING THE INTERIOR OF THE MOLD IS SUPPORTED ON A CAST IRON ARBOR

Foundry Well Equipped

This foundry is equipped in a special manner for the production of all kinds of heavy castings that enter into the construction of electrical power installations. The turbine exhaust hood castings shown in the accompanying illustrations are fairly typical of the work and the methods employed in handling it. The high brick and steel building is exceptionally well lighted and is equipped with four electric traveling cranes made by the Morgan Engineering Co., Alliance, O. One crane has a lifting capacity of 50 tons, a second is capable of lifting 40 tons and the remaining two are rated at 30 tons each.

Iron for the castings is melted in two cupolas, one 72 inches inside the lining, the other 84 inches. One was supplied by the J. W. Paxson Co., Philadelphia and the other by the Whiting Corp., Harvey, Ill. The cupolas are located side by side and are served from one charging platform. The two cupolas combined have an approximate hourly melting capacity of 57 tons.

Shop scrap, gates, sprues, defective castings, etc., are loaded in steel boxes and transferred by one of the cranes to an extension from the charging platform projecting under the crane runway in front of the cupolas. This feature may be noted at *A* in the two illustrations Figs. 2 and 3. The scrap is collected by the night men and loaded into pans and by lifting it to the platform by the crane, a considerable amount of trucking is eliminated and in addition, the elevator is relieved of a corresponding number of lifts.

The cleaning room, partly shown in Figs. 2 and 3 is separated from the molding department by a brick partition about 10 feet high. The partition is high enough to separate the floor into two compartments and yet low enough to permit the cranes to convey loads from one end of the

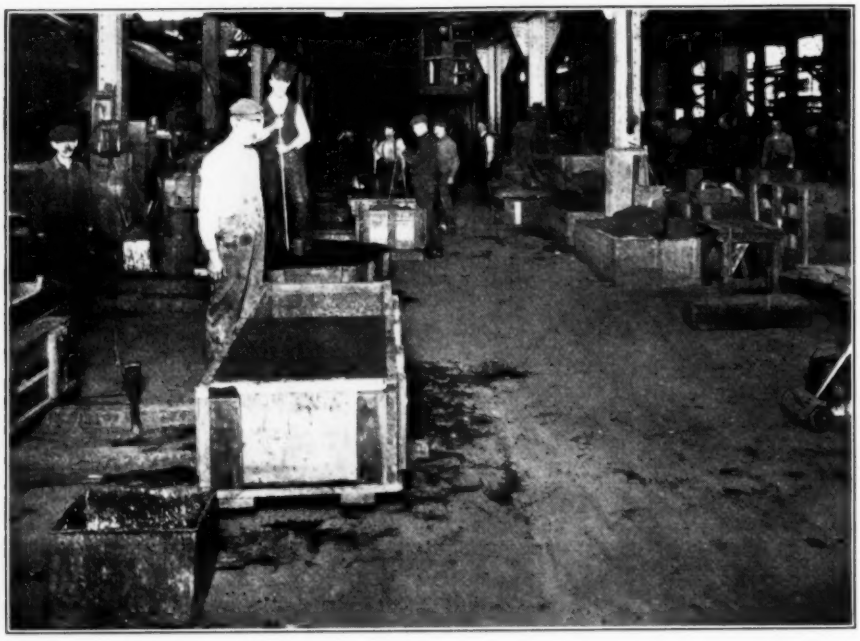


FIG. 5—THE CORE ROOM IS MAINTAINED AT ALL TIMES IN AN EXCEPTIONALLY CLEAN AND TIDY CONDITION

building to the other. A narrow gage track along the center of the main bay extends the full length of the building and also connects with other tracks in the yard thus facilitating the passage of heavy flasks and other material into and out of the foundry. The cleaning room is paved with wood blocks, the floor of the core room is made of concrete smoothly surfaced and the molding floor is made of sand.

Order and neatness, notoriously difficult to maintain in a foundry devoted to the manufacture of large castings are both greatly in evidence in the foundries of the General Electric Co., but nowhere perhaps more so than in the core room shown in Fig. 5. Many of the large molds are made almost entirely in cores and for that reason the core room is almost as extensive as the foundry.

Molded in Pits

Several pits are provided in the floor for the purpose of enclosing molds for large castings, typical examples of which are shown in Figs. 2, 3 and 4. From the front and back views of the turbine exhaust hood shown in Figs. 2 and 3 it will be noted that the walls were formed by a large number of cores. This arrangement gives in effect a dry sand mold, but one that is more flexible, easily assembled and readily dried than in instances where the mold is formed all in one section according to usual practice. An example of the latter method is shown in Fig. 4, showing a pattern which also serves as a corebox for a turbine exhaust casing. The illustration also shows the body of sand forming the entire interior of the mold and in addition the general features of the cast-iron pit above the floor level.

The pattern was made in one of the company's other plants and designed to be molded convex side down and with the large body of sand forming the interior suspended from the cope. This plan did not appeal to the Schenectady foundry executives and a set of rigging was developed to mold the pattern in the manner indicated in the illustration.

The pattern was leveled on the bottom of the pit in such manner that the upper surface was flush with the top flange on the casing. Sand was rammed around the outside up to the line *B* Fig. 4. A heavy cast iron arbor, two ends of which are shown projecting from the sand at *C* Fig. 4 was adjusted on suitable stands and then the inside of the platform was filled with sand, rodded where necessary and rammed. The sand was struck off flush to form a vertical parting on the face of the pattern and this face of the mold afterward was covered with loamed plates. A parting was made immediately above the arbor shown at *C* and sand to form the semicircular section of the mold was rammed on a suitable lifting plate. A second parting was made on the outside of the pattern along the line indicated at *B* and a lifting plate set on to carry the body of sand forming the outside of the mold up to the top of the pattern. A number of covering cores served to complete the mold.

The pattern was made in several sections and held together temporarily by dogs during the ramming process. After the sand had been rammed to the top, the back lifting plate with its body of sand was removed first. The top section of the pattern then was drawn out of the sand followed by the semicircular inner body of sand supported on the semicircular lifting plate. The inner section of the pattern then was withdrawn laterally after which the crane was hooked onto the main core as shown to the right in Fig. 4. After the large core had been removed, the remainder of the pattern was taken out and the mold was finished, blacked and dried.

After the mold was reassembled, loamed plates were laid vertically up against the facing flanges. The plate at each end was provided with openings corresponding with similar openings in a vertical row of gate cores rammed up in the sand employed for backing the plates.

Cranes Remove Castings

To facilitate lifting this and other castings of a somewhat similar character, two heavy chains are buried in the sand bed under the pattern. The ends of the chain are carried up and supported near the top of the pit casing. After the casting has cooled sufficiently the crane, or if necessary, two cranes are hooked to the chains and the casting with all the adhering sand is lifted bodily out of the pit. As stated previously the outside of the mold is formed from dry sand cores and those that do not adhere to the casting easily are removed afterward. This method of lifting the casting does away with a vast amount of shoveling, especially where several castings are to be made in the same pit.

Japanese Foundries Gain

Production of steel castings according to figures given out by the iron and steel industry of Japan through the department of commerce at Washington show an increase for 1922 over 1921 of 17 per cent. The output of steel castings for 1921 was 32,167 metric tons. Figures for 1922 are available only for the first six months, but show a total of 19,746 metric tons.

The Lava Crucible Co. of Pittsburgh has recently purchased several acres of land and buildings adjacent to its plant at Zelienople, Pa., for possible expansion.

Refractory Requirement Rigid

Lack of Suitable Material to Successfully Withstand the High Temperatures and Severe Operating of the Electric Furnaces Has Retarded Its Development—Longer Life of Roofing and Lining Sought

BY CLYDE E. WILLIAMS

ONE of the most important problems before the electric furnace industry is that of obtaining suitable refractories, the lack of which perhaps more than any other factor has held back a more rapid development of this industry. Naturally, the requirements for the various types of electric furnaces are different. An ideal refractory would be one of universal application, but, unfortunately, such a refractory has not yet been developed and probably never will be. The present tendency toward better heat insulation for the purpose of conserving as much energy as possible increases the demands made upon the refractory.

Fire clay, silica, and magnesite are in most general use for electric furnace work, probably because they are comparatively cheap and were already in wide use in fuel-fired furnaces, and, hence, available for use in the more recent electric furnace industry. The fact that these relatively cheap refractories are now generally used does not mean that a refractory with a higher first cost would not be accepted by the trade. On account of the high cost of repairing and replacing linings, more expensive refractories could be used if linings of longer life were produced thereby.

It is difficult to list the requirements of refractories for use in so broad a field as that covered by the electric furnace industry. Each furnace and each process has its individual conditions that must be met, but certain general requirements that apply in most cases may be outlined.

A high fusing temperature is important. This fusing temperature should be determined under a load greater than that under which the refractory will be used. If the refractory lining is used without insulation, and its heat conductivity is high, that portion of it farthest from the heat will be relatively cool and a greater load will be supported than is indicated by the load test. High heat conductivity also is an advantage in refractories used for the construction of externally-heated muffles and of resistor troughs in resistance furnaces. Expansion or contraction with temperature changes causes spalling if the furnace is subjected to rapid changes in temperature. Constancy of volume, therefore, is an important requisite.

Excessive shrinkage may occur in some brick when heated to a temperature higher than that at which they were fired originally, causing them to drop out, or the roof to slump. Refractories containing oxides, as, for example, oxides of calcium, iron, magnesium, silicon, aluminum, etc., will tend to form fusible compounds with the constituents of the slag, while such refractories as carbon, carbides, nitrides, etc., may at high temperatures be oxidized by some of the oxides contained in the slag. Gases and fumes rising from molten baths have the same chemical action on the refractory with which they come in contact as do similar constituents of the slag. Metals corrode linings largely by their physical abrading action, although they may actually react with the refractory material, as for example, carbon or silicon carbide may be dissolved by molten steel. High electrical conductivity is undesirable for refractories in most cases, although this property is sometimes used to advantage by those furnaces using a conducting hearth.

Temperature Near Softening Point

In the melting or refining of steel in the electric furnace, the temperature of the metal is raised to about 1800 degrees Cent., a temperature approaching closely to the softening point of many of the refractories in general use and far above that of some. It is evident that the linings of most furnaces must be heated to a higher temperature than this. There are two general processes used in melting steel, namely, the acid and basic processes. In the acid process, the side walls and roof are constructed of an acid refractor, such as silica brick; an acid slag is used, and no refining is done. Consequently, the charge is melted rapidly and is not held in the furnace for a long period of time. As a result, overheating of the refractory, fluxing of the side walls by the slag, and corrosion of the roof by volatilized lime are not excessive.

In the basic process, a basic lining, such as magnesite, and a roof of silica are ordinarily used. A slag of high-line content is placed over the charge, and the molten steel is held for a long period of time to permit the refining to take place. As a result, the lining becomes overheated and a large amount of lime is volatilized from the slag. This lime is an active flux for siliceous materials and causes early deterioration of the roof. The lime slag used usually contains silica which, at the high temperature prevailing, attacks the refractory at the slag line. In either process the close proximity of the electric arc to the side walls will cause superheating and destruction of the lining near that point. Magnesia is decomposed by carbon at a high temperature and is badly corroded by the arc. Iron oxide, if present in the refractory material used for the bottom, may dissolve in the hot iron and thus introduce oxygen to the metal, increasing the refining difficulties.

For economy of construction and operation, the roof should be as close to the metal as practicable. This would require a refractory of higher softening point under load. A refractory of too high heat conductivity would cause too large energy losses and one whose heat conductivity is low, or one used with insulation, would have to withstand higher temperatures under load. The refractory material for both the walls and the roof should withstand the high temperatures under load, should be inert both toward the acid and basic constituents of the slag or the fumes, and should be unaffected by molten steel. In many instances, it should withstand rapid temperature changes without excessive spalling.

The direct arc type furnace is in widest use in this country for steel melting. In this furnace, heat is transmitted to the charge by an electric arc which passes directly from the electrode to the metal and by reflection from the roof and walls which are heated by the arc. These furnaces are built in large sizes and the refractories, especially those in the roof, are under large mechanical stresses and should withstand more severe load tests than those used in some of the other types. On the other hand, the heat is not concentrated in so small a volume as in the case of the smaller furnaces and there is not the high degree of overheating by the arc. In those furnaces using a conducting hearth, refractories for the bottom should have high electrical conductivity.

The indirect arc furnace is used in

From a paper presented at the Pittsburgh convention of the American Ceramics society, Feb. 12-16. The author is superintendent, Northwest experiment station, United States bureau of mines, Seattle, Wash.

steel melting practice, and there are several different varieties of this type of furnace in use. In the indirect arc furnace an arc is struck between electrodes placed above the charge and the heat is transmitted to the metal by radiation from the arc and reflection from the walls and roof. On the whole, these furnaces are smaller than most of the direct arc furnaces, and, hence, the refractories may receive more local overheating, but, on the other hand, the load impressed is not so high and, as a result, the refractory would withstand a higher temperature than it would in the larger furnaces.

The induction furnace has not been generally introduced to steel melting practice in this country, although many advantages are claimed for it and it is in wide use in Europe. A 2-ton furnace has been in successful operation in Pittsfield, Mass., and two others are said to be in operation in this country. One factor which has kept the induction furnace from developing more rapidly has been the difficulty of obtaining a suitable lining for the hearth. A satisfactory lining for basic operation has been developed for the aforementioned furnace at Pittsfield, with which 604 consecutive heats have been obtained. The induction furnace is essentially a transformer whose secondary coil consists of a ring of the metal which is heated by the electric current induced from the primary winding. The induced current gives rise to circulation of the metal which should keep the temperature of the lining uniform and prevent local overheating. In the induction furnace there are no electrodes, the heat being generated in the metal. Hence, the slag is at a lower temperature than in similar operations in other types of furnaces and there should be less corrosion of the roof by ascending vapors.

High Refractory Material Required

The resistance furnace has not been introduced into steel-melting practice, although one instance of its use for melting steel scrap in an experimental run has been recorded. In the operation of this furnace, most of the heat is transmitted to the metal by reflection from the roof, while some comes from the troughs containing the resistor material. Undoubtedly, the refractories in this furnace used for steel melting would be subjected to excessive temperatures. If this furnace is used commercially for melting steel, it would be desirable, in order to prevent excessive losses of heat, to find a refractory for the roof that will withstand temperatures considerably greater than do those which are now in common use.

The conditions in the operation of iron-melting furnaces are similar in almost every respect to those in steel melting, except that the metal is held molten at a lower temperature, not over 1400 degrees Cent., and usually less refining is done. In the duplex process, hot iron comes from the cupola and is finished in the electric furnace. Thus, the temperature changes are not great and spalling troubles are lessened. In melting cold scrap or pig iron, however, rapid temperature changes are experienced. In general, the statements made above in regard to steel melting apply here except that none of the conditions mentioned are quite so severe in the melting of iron. Intermittent operation with the subsequent cooling of the furnace subjects the lining to severe spalling action, and, inasmuch as it is desirable in foundries to operate intermittently, it is highly important that the refractory be relatively free from volume changes when passing through relatively rapid temperature changes between the limits of about 1500 degrees Cent. and normal temperatures.

In most nonferrous melting practice the temperatures used are relatively low. In many cases the highest temperature to which the metal is heated is about 1100 degrees Cent., the temperature of the lining in some furnaces being raised considerably higher than this. Since these furnaces are for the most part quite small, running usually from one-fourth to two tons in capacity, the heat is more concentrated in the crucible and the refractory lining subjected to more severe heating than would be the case in larger furnaces. The load under which these refractories are held would be relatively small and the requirements in this direction would therefore be less. The intermittent methods of operation with the resulting temperature changes subject the refractory to spalling, although this is avoided in some furnaces by keeping a small load on during periods of rest in order to avoid the necessity of heating up before the next melt.

Absence of slags removes one important requirement, but the corrosive action of some of the fumes, particularly in the case of lead, adds one in its place. The washing of the metal over the hot surface of the lining in the rocking or rotating indirect arc furnace causes a more even distribution of heat than is found in the stationary types. The high concentration of heat at the roof of the common resistance furnaces makes particularly heavy demands upon the roof. An important problem in the nonferrous alloy field is the development of a refractory that can be used in melting alloys of high lead content. This is of particular significance in the case of the vertical ring induction furnace. The high-frequency induction furnace makes possible the easy attainment of temperatures higher than those usually employed, and it is highly desirable that a satisfactory refractory be developed for this use.

If the electric smelting furnace is designed properly, there is less failure of the lining than in furnaces used in the various melting practices referred to above. Of course, there are exceptions to this statement, because in some smelting operations, products are formed which attack almost any lining that can be used and in such cases the success of the process depends upon the development of a suitable refractory. Most smelting furnaces are of the open top pit type, the electrodes being inserted into the charge and the heat generated by the resistance of the charge to the flow of the electric current and by small submerged arcs playing between the particles of the charge. The most important refractory trouble is due to corrosion of the lining by the chemical actions of slag, metals, or vapors.

Must Withstand Basic Slag

In the production of ferromanganese, a refractory is required that will withstand the action of a basic slag carrying a high percentage of lime and manganese, and, in addition, some silica and alumina. This slag attacks both basic and acid refractories. Such refractories as carbon or silicon carbide should withstand the action of the slag better than any of the others but they reduce manganese and iron oxides at the high temperature prevailing and are also soluble in the hot metal produced. However, both of these refractories have given satisfaction in practice. Magnesia withstands the action of the slag well and also is not attacked by carbon at the temperatures used. It may, however, be attacked by the arc if an electrode is pushed near the wall and excessive arcing occurs. Magnesite grout rammed with pitch has given satisfaction in a number of instances. Fire clay and the acid refractories are more readily attacked by the basic constituents of the charge, but have proved satisfactory when used in thin walls cooled by air or water, which arrangement cools the charge and causes it to solidify on the lining and thereby form a new lining.

No serious refractory difficulties are experienced in the operation of ferrosilicon furnaces. The crucible of these furnaces usually is lined with rammed carbon or carbon blocks and the wall is made up of silica or fire clay brick. The charge consists of quartzite or high silica content, rich iron ore or scrap iron, and coke or coal. The production of slag is avoided as far as possible the attempt being made to reduce all of the con-

stituents of the charge to metal. The fusing temperature of the charge is so high that the walls of the furnace are soon covered with a refractory layer of partly fused silica which protects the lining from further action. Carbon is a satisfactory material for the crucible lining because it is not dissolved in ferrosilicon and a sufficient excess of carbon is used in the charge to protect the lining from oxidation.

Ferrochromium, ferrovanadium, ferrotungsten, ferromolybdenum and some of the other less common alloys ordinarily use a carbon-lined furnace either made up from rammed carbon and pitch or carbon blocks. In some cases magnesia is used. Carbon should be satisfactory in most instances, but cannot be used in the production of low carbon alloys, such as low carbon ferrochrome, in which carbon is quite soluble. In such cases, a lining made up of the ore being treated proves desirable as, in ferrochrome practice, chromite has proved satisfactory; or a basis lining, such as magnesia, may be used to advantage.

One of the disadvantages of carbon or silicon carbide in these small alloy furnaces is that both carbon and silicon carbide conduct the electric current, and unless the furnace is designed to avoid it, a large portion of the current will flow through the walls and not into the charge, thereby producing a cold bottom and other irregularities in furnace operation. Such materials as carbon and silicon carbide are also good conductors of heat, and, in order to avoid too great heat losses, should be well insulated.

Requirements for Ferroalloy Linings

To solve all of the refractory problems connected with ferroalloy smelting a refractory should possess the following properties: Relative inertness to the action of the slags used; freedom from oxidation by iron oxide or the other metallic oxides present; insolubility in molten ferroalloys; low heat conductivity and low electrical conductivity, and freedom from spalling when used in furnaces operating intermittently. The principal lining consisting essentially of the charged material may be used advantageously. This practice, however, increases the heat losses and prohibits the use of a single furnace for the preparation of a variety of alloys consecutively.

The furnaces for melting alumina, magnesia, spinel, sillimanite, etc., take advantage of the principle mentioned above, namely, the cooling of the walls and the freezing of a part of the charge on them. In this case, however, a steel shell alone is used and is cooled either by air or water. A suitable lining is readily formed by the solidification of the material being melted. This practice entails a large loss of energy by the conduction of heat through the walls, but is probably the best practice when it is considered that the temperatures used—(from 1800 degrees Cent.) are greater than any that the present developed refractories are able to withstand. Furthermore, it would be quite impossible to develop a lining that would not react with molten oxides at these high temperatures.

Fire Clay Brick Can Be Used

In the operation of furnaces used for the production of calcium carbide, a temperature above 1800 degrees Cent. is required. Lime and carbon are used in the charge and it is to be expected that either a carbon or a basic lining would be necessary. However, fireclay brick can be used because the fusing point of the calcium carbide is so high that some of it solidifies next to the relatively cool lining and protects it from the action of the heat and charge.

No furnaces are in operation in this country for the electric smelting of iron ores, although there are a number in Europe and two have recently been installed in Brazil. Two kinds of furnaces are used, the shaft type and the open top or pit type. The shaft furnace consists of a crucible or hearth, and, resting upon this, a shaft. The hearth usually is lined with dead burned magnesia rammed with pitch. It is covered with an arched roof through which electrodes extend into the crucible. The roof consists of fire brick cooled by the circulation of gases which pass through tuyeres into the hearth just under the arch, thence up through the stock and, after being cooled, return to the tuyeres. The roof is the weakest point in the construction. It is probable that this furnace will be replaced in future developments by the simpler pit furnace. In the pit furnace the operations are similar to those of ferromanganese smelting and the refractory requirements are alike in both cases.

Important recent developments have been a wider use of high aluminous fire clays and higher temperatures of firing. The addition of aluminum oxide to fire clay in various amounts up to and even greater than the content of sillimanite, Al_2O_3. SiO_2 has produced refractories that have been satisfactory in many instances. The presence of the excess aluminum oxide increases the fusion temperature and in many cases reduces the corrosion of both slags and gases. These mixtures have given satisfactory results in the roofs of a number of different types of furnaces, especially those of short span where the pressure has not been great. Bauxite brick are giving more satisfaction now that they are being burned at higher temperatures and all of the shrinkage has been taken care of before they are put into use.

The so-called superrefractories are coming into wider use and more fundamental information is being obtained regarding their properties. Silicon carbide now is a rather common article and its properties are well known and have been described in the technical literature. Fused magnesia is coming to the fore, but satisfactory methods of bonding it are not generally known. Moreover, it is not definitely known whether fused magnesia will be more satisfactory for general use than properly made dead burned magnesia. A well conducted comparison of these two products is needed.

Fused alumina, sillimanite, and spinel, $MgOAl_2O_3$, zircon, and many others are being experimented with and used in commercial operations to some extent. Each one has given encouraging results and, although the pure synthetic compounds have shown remarkable properties, complete knowledge of the fundamental refractory properties of these various materials, as prepared commercially, are not yet available. The commercial product will contain impurities, and it seems important that work of a fundamental nature be done on the commercial grades of these products. In practically all of the superrefractories now under consideration, the inability to develop a suitable bond and the difficulty of firing the brick to high enough temperature have been important factors in holding back widespread application of these materials.

Erects Gray Iron Shop

For the purpose of increasing its facilities to better handle its volume of business, the Ouachita Iron Works, Inc., Monroe, La., recently was incorporated with a capital stock of $40,000. The company now is erecting a new plant building and is adding a foundry which will enable it to produce gray iron and bras castings. Officers of the company are: President and general manager, M. W. Anthony; secretary and treasurer, L. J. Anthony and vice president, J. B. Anthony.

Melts with Oil in Air Furnace

Coal-Burning Furnaces Used To Melt Malleable with Slight Changes in Combustion Chamber—Figures Given Showing Relative Cost of Coal Firing and of Oil Firing—Oil Consumption Recorded

BY D. I. DOBSON

THE increasing cost of good melting coal, high freight rates, diminishing supply, etc., is causing malleable foundries to consider other fuels than West Virginia coal as a melting medium. The extreme simplicity of converting a coal-fired furnace for the use of fuel oil, ease of handling, and lowered melting costs, have caused malleable foundrymen to consider the use of oil. Unfortunately some pioneers in this field have been unsuccessful in obtaining uniformly good heats. Oil fuel has thus received at the outset a reputation of being tricky, excessively oxidizing, and uncertain.

As early as April, 1921, the Sampson Tractor Co. division of the General Motors Corp. experimented with fuel oil for melting purposes at the plant of the Waukeshaw Malleable Iron Co., Waukeshaw, Wis. For more than 6 months four furnaces have been operated successfully with oil. One furnace has been in constant operation since June, 1921.

The only change necessary upon the furnace is the conversion of the combustion chamber as illustrated in the accompanying illustration. The firebox must be filled in on top of the grates with ashes, cinders, broken firebrick, or any available refractory material. Two inner walls should then be constructed on top of this filler to form a V-shaped combustion chamber, 10 to 12 inches apart at the burner end, and spreading to the full width of the furnace at a point slightly in advance of the front bridge. The burner may be introduced inclined toward the iron horizontally, or up away from the iron. This company has experimented with the burner inclined rather sharply toward the iron, but has obtained the best results with but a slight inclination toward the bath with the burner about 2½ feet above the level of the bath. The floor of the combustion chamber is filled with firesand, and conforms in slope with the pitch of the burner.

To lengthen the combustion chamber somewhat a small box-shaped addition has been made. It is supported by 3-inch channels with 1-inch steel stringers bolted to the furnace plates at one end, and uprights, formed of 1½-inch pipe at the other end. With this addition the combustion chambers measure a trifle over 8 feet from burner to front bridge.

A good burner is one which atomizes the oil thoroughly. Either steam or compressed air may be used to effect atomization. In this installation air at about 70 pounds pressure has given the most satisfactory results. Many types of burners are on the market, some designed especially for air furnaces. We are using home-made burners, and find them satisfactory. The burners are introduced through a cast-iron T. The front blast is brought in through the bottom of this T. Some plants have placed the front blast above the burner and some below. We have experimented with the burner above the blast, but found the effect highly oxidizing.

Flame Requires Adjusting

The oil flame is different from the coal flame in several respects, namely, the manner in which combustion occurs, and the shape of the flame produced. The flame may be compared favorably with a gas flame. There is first of all a zone of combinations, and then a zone of completed oxidation. These zones, of course, grade into each other, but may be shortened or lengthened at will by supplying more or less air through the front blast.

Our practice is to start with the front blast set at its maximum. This causes combustion to take place early and gives a hot fire at the front of the furnace, though the flame is quite short. The iron starts to drip in front within 35 to 45 minutes on a cold furnace, and in 20 to 30 minutes after recharging.

The oil is fed so that at no time is there a great amount of smoke coming from the top of the stack. After the iron starts to drip, the blast is cut to lengthen the flame. The hottest zone of the fire is thus worked gradually through the furnace. However, care must be taken not to move the blast too quickly, or the melting will be hung up in the part skipped over.

Dampers have been installed on the top of each stack to aid in maintaining a uniform pressure in the furnace when reducing the amount of air of the front blast. The top blast is led in through five 2-inch pipes at a point slightly beyond the old front bridge. It is kept wide open all through the heat.

Some poking and skimming is necessary on the part of the operator, though his work is light when compared with that of the coal fireman. A good illustration of the comparative work is that during the hottest weather of last August one man operated a furnace, while on similar occasions heretofore three firemen have been used.

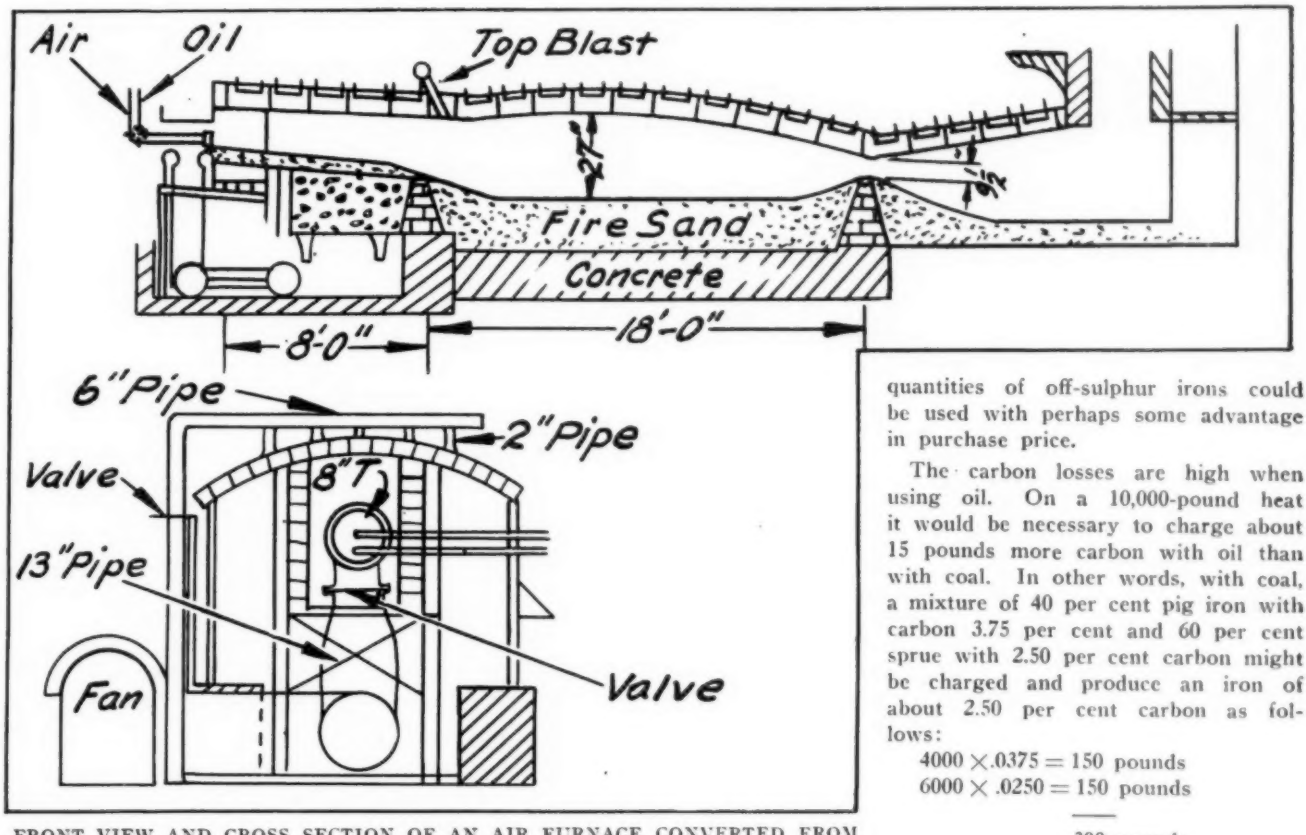
Oil pressure is maintained at the pumps at about 90 pounds. Each pump feeds two furnaces, and since a line drop occurs, the first furnace receives oil at 80 pounds pressure, while the second receives oil at 60 pounds pressure. The pressure is not of real importance except that it insures a proper volume of oil flowing through the burner orifice. The oil line valves are never opened more than a turn and a half and at times heats have been melted with oil pressure at 20 to 30 pounds.

Air pressure at the burner, which is used to atomize the oil, is more important. We have found that better atomization is effected with air pressures over 50 pounds. The air pressure varies at times from 50 to 85 pounds.

Air for combustion is delivered by a fan, the tip diameter of which is 42 inches and width of blades 12 inches. It makes 1050 revolutions per minute. Air is discharged through an opening 13 inches in diameter. The top blast is taken off this 13-inch pipe by a 6-inch pipe and is delivered through five 2-inch pipes from a 6-inch header. It is estimated that neither front or top blast is under more than 10 to 12 ounces pressure, although this has not been verified.

The equipment necessary for the use of fuel oil consists of tanks for stor-

Paper read at a recent meeting of the Milwaukee Malleable club, Milwaukee.



FRONT VIEW AND CROSS SECTION OF AN AIR FURNACE CONVERTED FROM COAL FIRING TO BURNING OIL

age, pumps and feed pipes. It is also desirable to have a return line.

Provision must be made for heating the oil in cold weather. Steam coils may be inserted in the tanks for heating purposes, though care must be used to prevent leaks in the coil, for water in the oil line is disastrous to the heat. Each storage tank should have a drain valve on one end, and should be given a slight pitch toward the drain. Water accumulates from fuel oil as it stands.

Pressure Gages Are Used

A return line is also of service during cold weather, for by keeping the oil circulating slowly at night it is possible to prevent the oil in the feed pipes from becoming gummy. This company is using fuel oil from 19 to 25 degrees Be. Such an oil flows freely at 70 degrees Fahr., though better satisfaction is obtained when it is heated to 80 degrees or higher. Difficulty will be experienced in maintaining suction at the pump if the oil be heated above 110 degrees Fahr.

We have found an oil-pressure gage and an air-pressure gage to be useful to the operator at the furnace. Indication is thus readily given in case of trouble either at the pump or compressor. Other miscellaneous equipment at each furnace includes an oil meter, strainer, pressure regulator, and a drain valve for letting out water should it by any chance get into the line.

We have worked with the conviction that a furnace has a rated capacity of oil per hour. Such capacity is that which will give at least 15 per cent carbon dioxide over the rear bridge. Carbon dioxide may be determined readily by any of the apparatus on the market for that purpose. The amount of flame over the rear bridge is a good indication of correct operation.

Morning heats require 5¼ hours from start to tapping, and second heats are taken out in 4¼ hours. Loss in silicon varies from 0.30 to 0.35 per cent on the morning heat, and from 0.20 to 0.25 per cent on an afternoon heat.

Loss of manganese averages 0.158 per cent. Some difficulty is experienced in keeping manganese low enough, though by mixing a 0.60-per cent manganese coke iron with a 0.35-per cent manganese charcoal iron, and sprue of about 0.28 per cent manganese. This element may be maintained below 0.30 per cent.

Fuel oil adds little if any sulphur to the iron which, in our case, contains an average of between 0.035 and 0.040 per cent sulphur. The low sulphur may explain the small losses of manganese. At any rate large quantities of off-sulphur irons could be used with perhaps some advantage in purchase price.

The carbon losses are high when using oil. On a 10,000-pound heat it would be necessary to charge about 15 pounds more carbon with oil than with coal. In other words, with coal, a mixture of 40 per cent pig iron with carbon 3.75 per cent and 60 per cent sprue with 2.50 per cent carbon might be charged and produce an iron of about 2.50 per cent carbon as follows:

$4000 \times .0375 = 150$ pounds
$6000 \times .0250 = 150$ pounds

300 pounds
$10{,}000 \times .0250 = 250$ pounds

50 pounds loss:

Equals 16.65 per cent of the carbon charged.

Whereas, with oil, it is necessary to charge 5000 pounds of 3.75 per cent carbon pig iron and 5000 pounds of 2.50 per cent carbon sprue to obtain carbon in the hard iron at 2.50 per cent.

$5000 \times .0375 = 187.5$ pounds
$5000 \times .0250 = 125.0$ pounds

312.5 pounds
$10{,}000 \times .025 = 250.0$ pounds

62.5 pounds loss:

Equals 20 per cent of carbon charged.

The effect is to lower the amount of sprue which may be charged. However, we have maintained carbons constantly from 2.30 to 2.50 per cent while charging an average of 48 per cent hard iron. This figure might be increased to 55 per cent if necessary by charging about 1 per cent petroleum coke on the bottom of the furnace with each charge.

Phosphorus is neither lost nor gained but comes in the iron in about the same proportions in which it was charged.

From 5500 to 6500 gallons of oil are consumed on each of the furnaces per week of 11 heats. The capacities of

(*Continued on Page* 466)

Discuss Apprentice Situation

Discussion of the Apprenticeship Situation by Men Who Are Connected with Plants as Supervisors of Apprentices or Connected with State Departments of Apprentice Training

BY W. S. SIMON

LABOR saving machinery has dispensed to a great degree with the services of the all-round molder. As a result little need of continuing apprenticeship training could be seen. While these changes were going on a sufficient supply of real molders remained in the field but practically all new men coming in, were, and have been ever since, men of no particular qualifications, except speed and physical strength—men usually of foreign birth. The demand was for laborers and not for mechanics.

In the meantime, while foundrymen pooh-poohed the necessity of apprenticeship training, the annual labor turnover among all-round molders, due to death and retirement, continued as usual. Today, the old time molder practically has disappeared. The argument may be advanced that the molder's trade has been so broken up by machinery and piece work that the molder no longer is needed. The machine shops have suffered no less than the foundries in this respect, but will anyone contend that machinists no longer are needed? It is true that under certain conditions it would be folly to employ all-round molders. The element of chance in the making of castings is greatly minimized by well constructed and fool proof patterns, and by well designed molding machines. On heavier work, found in many foundries, the service of real molders becomes necessary. They must be skilled men with judgment developed through years of experience on a diversified class of work. The value of these men lies in the fact that they do not need the foreman or superintendent to stand over them every minute. In the end these prove less expensive due to lower labor turnover and to less material spoiled.

Modern mass production necessitates the employment of specialty workers. But there is danger in carrying it too far. We are too likely to overlook the disastrous effects it has on the individual worker. Instead of developing intelligent citizens, craftsmen who take pride in their trade, we are turning out narrow, prejudiced and ignorant workmen, who for want of training, swell the ranks of the unemployed the moment the slightest depression in their particular line of work occurs.

Let us grant that at least a number of the foundry workers ought to be skilled molders and that apprenticeship training has fallen into decay for various reasons. How can we revive the trade?

Before a beginning can be made foundrymen must agree on a few, though important, preliminaries. What type of work is the journeyman to produce? What course of training and how long will it take, to develop a journeyman capable of performing the work.

Employers Must Co-operate

Individual employers of skilled men in any trade readily agree that apprenticeship is vital—that the only reliable method of making journeymen is in the shop on the job, but not in their shop. The biggest problem of apprenticeship is selling the idea to the employer. They do not like to be told this but nevertheless it is true. Probably it is no easy matter to interest him because immediate profits do not exist, or probably because he can dispense with apprenticeship for the time being and depend on fate or his fellow employers to do the training.

Each foundryman who employs all-round molders must agree to give his wholehearted support to the cause or it hardly will pay to begin.

Where are apprentices to be recruited? Will boys take to the foundries as soon as foundry operators declare themselves willing to hire apprentices? It must be remembered that many other trades, more attractive than the molder's in outward appearances are only too anxious to secure learners. Because of the nature of the work and because of the attitude of the present day boy toward hard work, the foundries must offer unusual inducements to prospective apprentices.

The beginning wage scale must be somewhat higher than is paid in other metal trades and ought to be nearer that paid for learners in the building trades. For instance machinist apprentices here earn about 20 cents per hour to start with while molder apprentices receive an average of about 38 cents with an increase of about 2 cents per hour every six months.

Unfortunately at present journeymen molders earn less than piece workers. Perhaps this will adjust itself later when molders are still more in demand. The fact that a molder is assured of continuity of employment, while the piece worker is not, is a good argument to use in persuading boys to learn molding.

The most attractive inducement that any employer can hold out to potential apprentices is to guarantee them a real opportunity to learn the trade. I cannot stress this point too strongly. Any number of young men can be persuaded to enter an apprenticeship with high wages as a bait but not until they have spent several months in it do they realize the genuine interest in them on the part of the employer is much more valuable than so much per hour. When it becomes necessary for an apprentice to ask repeatedly for a class of work to which he is entitled but does not receive, or when he sees that he is treated as a helper, or as a necessary nuisance around the shop, he quits in discouragement and leaves the trade entirely or goes to another employer whom he knows will give him proper recognition. The employer who can show his apprentices, who earn only 20 cents per hour, that he is sincere in his desire to give them every chance to learn the whole trade, and not depend entirely on the whims of his foreman, will have a more successful apprenticeship system than the employer who pays his apprentices 60 cents per hour but who expects the learner to pick up the trade while performing helper's or laborer's work. Incidentally, an employer who is ready to offer a genuine apprenticeship training ought not to hesitate to put his proposition in writing in the form of an indenture. Let the apprentice

and his parents know that it is a bona fide apprenticeship and it will lead to a better understanding on all sides. Prospect of a bonus of $50 or $100 at the end of the successful completion of the apprenticeship works wonders.

Too often apprentices are hired because they happen to be at the gate when the job is open, or because they happen to be related to an employe. It is surprising to learn how little the average boy knows of the opportunities open to him in the trades. He works at odd jobs that bring no return in training until a time when he no longer can afford to work for apprentice's wages. The time to reach these boys is when they are attending the continuation school. While perhaps they might be too young to perform foundry work, descriptive literature of the industry will at least start many of them to thinking of it. In Milwaukee we reach the older boys as they apply for work at the employment office. By interviewing them and pointing out the advantages of an apprenticeship many are induced to enter the trade as learners.

Problems in Training

By E. A. PARKER

IN THIS age of intensive training why should it be thought inadvisable to train the younger generation in the details of foundry practice? We train men for our office in all its various branches. We have produced cost engineers, factory managers, superintendents and foremen and the like by recognizing the advantages of special effort and applying the principles of value in each individual class. If the many evidences of success merit a continuance of this policy we firmly believe it should be extended to take in the manual trades. Personal efficiency courses are needed for the man who wields the shovel as well as by those who use the pen. If special training yields returns in one case it will also in the other.

The advent of special equipment of various kinds has had much to do with weaning the mind away from its earlier conceptions. So much stress has been placed on making every molder a 100 per cent machine that the need of apprentices to carry on the initiative when our present stock of mechanics has been depleted, has been overlooked.

At this writing there is a dearth in many of our foundries of molders who have been taught to use their brain as well as muscle, and if the intensive training so much in vogue continues to exclude the youth of our foundries it will not be oustide our own vision when the decadence of our skilled mechanics will constitute a menace.

The installation of productive or super-productive apparatus in our foundries should not by any means remove the need of apprenticeship in the deeper principles of molding or in meeting the unfolding problems of the day, and in fact can not do so. Not all of our work can be accomplished by mechanical contrivances and there remains the vast field where success is measured only by the individual skill of the trained workman.

In one of our Ohio factories the other day a man applied for a job. When asked where he had previously worked he named the factory where by mechanical principle the most popular car is produced at a very nominal price. On being pressed further as to what he did he exploded—"I put in that damned No. 29 screw." If our aim as foundrymen is only to produce this type of a cog we have no excuse for forcing apprenticeship on our youth. But we believe the higher ideals of the American mind will evolve a better scheme of life, and a partial reversion to, or a better adaptation of, the methods of other days will reveal much of material good for our foundries.

Form of Contract Necessary

Should the theory of apprenticeship ultimately be accepted, the problem of the contract between employer and apprentice will be found to have real but not unsurmountable difficulties. Our youngsters of today have little inclination to bind themselves to work for a small wage and some inducements as to training and future prospects will have to be devised that more nearly approximate the changed condition of these times. We do not believe the average youth of today is different from the youth of yesterday but he of today has to live under the burden of an increased overhead. If he does not view the apprenticeship in the same light as he does the training of the approved universities it might appear to him as an unequal bondage and unworthy of serious thought. The employer, naturally will not wish to provide training for philanthropic reasons only and will want to see some real return from the effort.

Just what will constitute a fair wage for the apprentice is a matter of real study, a problem of conditions, and the employer having met these conditions must have some guarantee of a return on his investment. Dead timber will develop in any course of training and that the employer would not be tied up to such by a long time contract it has been suggested that contracts between the interested parties should be based upon a recognition of the possibilities of the case and provision should be made for a short probation period, after which at the option of both parties the contract could be renewed for the proper term of service. The trial period might be placed at six months or less. It might be possible to make a practical application of the bonus system to this case should the apprentice fulfill conditions in a suitable and successful manner. If a per cent, based on his weekly wage, should be allocated to a fund that should be his upon a successful termination of his apprenticeship, a sufficient inducement to a closer application to his own and his employer's interests would be provided. That some such written contract, along these or other lines, should be the basis of all effort toward apprenticeship is evident. Its validity is undeniable and the impress of responsibility is with it.

Any system of training devised, to be thorough, should include an apportionment of time in all the various departments of the foundry, but the advisability of such departmental or general apprenticeship might well be the answer to the question "What do you intend to make of him?" If all you are expecting is a furnace man there will be small returns on an investment based on a general instruction policy. In this respect, however, we can but admire the forethought of the management of one of the larger factories of our city, who insisted that their pattern-makers apprentices should be taught the rudiments of the foundry game in order to broaden their vision and develop ideas in conformity with foundry practice. How much the foundrymen of our land would have been spared of disappointing labor and departmental disputes had this practice been general.

Our schools are filled with potential

presidents, governors, literary men, bankers, etc., and with thousands of units that must of necessity fill positions more closely allied to productive labor. These are thrown upon the labor market at an age where unprofitableness in proportion to a possible wage is apparent. It is possible that an intelligent modification of existing laws, allowing for instance that a lad be permitted to leave the public school at an earlier age on the employer's certification of apprenticeship, would relieve the unequal condition. In later years this failure of the schools to meet the requirements has been recognized and manual training has found place as a means of filling the gap. It is only partially successful. Future jewelers are taught the intricacies of carpentering; future carpenters are initiated into the veiled secrets of the metal industries; only a few reach the holy of holies—the trade best suited to them.

Training Given Thought

Our nation's foundries daily are spending millions in investigating newer methods, analyzing intricate chemical problems, seeking to build on a firmer foundation the structure of metal adaptability and use. In some respects these great institutions resemble, and in some respects surpass, in constructive thought and practice, our noted pioneer universities. It suggests to our mind that a possible fertile field of usefulness, as expected by the manual training effort, is nullified if these factories that are so advantageously and courageously spending their millions in selfish ends elect to withhold their help from the public school. From our conversations with instructors we have absorbed the thought that they would welcome the interest and co-operation of foundrymen. One instructor has called on executives of our acquaintance asking that school instruction be amplified by employment after school hours. Such action made general might help the situation to a great extent, but we feel it cannot in any way, from the foundrymen's standpoint, equal in results the special training possible under exclusive foundry control.

We, like many other employers, have allowed the apprentice to slip away from us. The labor involved in the training measured by the old time standards, has seemed to be unproportionate to the service received. Changing times with new methods, unselfishness combined with practcial ideas may bring about a profitable readjusment for us all. It may even be a monument to American industry. We need the apprentices.

Segregate Apprentices

By F. W. KIRBY

DURING the last twenty or twenty-five years, we have seen many radical changes in the operation of our foundries. We have seen the introduction of the many various types of molding machines, material handling devices, sand cutting and tempering machines, continuous pouring systems, and many other changes, all of which have brought about an entirely new conception of the class of help required in our foundries. Under the old conditions, a molder was a man who could turn out a perfect casting of any size or kind, almost regardless of the equipment available; his skill constituted about 90 per cent of the equipment. Today in our production foundries the trade has become highly specialized, and has been divided into several branches.

We now have foundries devoting all their efforts to the production of one general type of castings, wherein the system of checking gages and inspection leaves little chance for the man operating the molding machine to go far astray. The largest number of foundries, however, probably will be found operating in connection with manufacturing establishments. In these foundries we find the greatest variety of castings produced. They often range from medium heavy floor work, down through the range of molding machines of different types, bench work, and on to the very lightest castings made from match plates on manufacturing establishments. In these types of foundries, all kinds of molders are required in large numbers, from the highly skilled all-around man to the specialist. In both of the types of foundries just mentioned, quantity production is an essential requirement.

Another important section of the industry devoted to the production of machine tools where the castings produced usually average much heavier than those in the other foundries. Also, the number of castings to be made from a given pattern is relatively small, thus making it unprofitable to install highly specialized equipment. It is obvious that while these foundries are classed as production foundries, they require a more skilled type of molders than the others.

The introduction of the molding machine and specialist molding undoubtedly has had its effect on the demand for the skilled molder, but not more so than the introduction of special machine practices has affected the demand for tool makers and machinists. The total number of molders and machinists has increased, and the shortage of finished workmen, or men who must think on their jobs, is as great, or greater, than ever.

Involves Short Course

In the first type of foundry mentioned, it would seem that the policy should be to bear down on the vestibule idea of training help. Each foundry, of course, would have to work this out to fit its own condition. The system should generally involve a short course of intensive training covering a knowledge of the sand condition, care of the pattern equipment and the necessary operation in the making of the molds with that particular kind of equipment. The training should be in charge of a thoroughly competent mechanic, in the apprentice a thorough knowledge of the shop policy. Wherever possible, or practicable, the preliminary training should be carried on separately from the production shop. In all large groups of workmen, a few always make it their particular business to get in touch with new help, and instruct them thoroughly in just how slow they should work, and in all the shortcomings of the management.

In the second type of foundry, the vestibule probably could be enlarged to cover a more extensive range of training. The general principle to be followed, should be the same in both cases for specialty men. In addition to the specialty men, it also is necessary to train men who can put up molds with less highly developed equipment. This refers to bench work and floor molding. Those students who, in their preliminary training, indicated the greatest aptitude for the work, should be induced to continue their training further. In many foundries a small section of the production department is reserved for this work. Here the new men are placed in charge of a skilled mechanic who will coach them along, giving them work which requires greater skill as they progress. The length of time required for this training will

depend entirely on the aptitude of the worker. A man taken into an instruction department, knowing nothing about the work he is to do, and getting started right, will develop into a skilled operator much quicker than the man who gets his misinformation from a wrong source, and has much to unlearn.

In the third type of foundry, the training will be of an entirely different nature. Here the requirements are for skilled, all-around, molders and helpers; the helper often developing into the skilled mechanic. In these foundries two practices are possible which will develop molders. In the first, the young man goes into the foundry as a laborer, is promoted to the position of a molder's helper, and finally is able to take on more or less simple jobs with success, and in due course of time becomes classed as a skilled mechanic. The other practice is that of carrying out a regular course of apprenticeship for boys just leaving school. The apprenticeship should include coreroom practice, all the different kinds of molding carried on in that particular shop and a study of different molding sands, etc.

The foregoing suggestions apply to the larger foundries. In the small foundry the problem necessarily is different. Here the training of the new man depends entirely on the activity of the foreman in charge. If he realizes the need for training new help, it is possible for him to carry on the training quite as successfully as it is done in the larger foundries, even though he has not the more or less elaborate facilities of the larger institution. In the small foundries usually several different kinds of molding operations are carried on. Although the majority of the molds generally will be made by hand on the floor or bench a few molding machines sometimes are employed.

Foreman Should Co-operate

A foundry foreman quite often starts the beginner in on simple parts, giving him the necessary instructions, and following this up frequently with advice and further suggestions, until such time as the beginner has mastered that particular job. If the number of castings required from that pattern will allow it, the apprentice usually will have enough confidence in his ability to try for larger output. As he progresses successfully, it will be mutual advantageous to change the man to other classes of work, and follow the same procedure. In this way the beginner will develop into an all-around production molder in the course of two and a half to four years, depending entirely on his ability and the co-operation of the foreman.

In some small foundries, it has been found advisable to have a small class of three or four beginners under the direct supervision of a skilled molder who, in addition to his regular work of making molds, will help the beginners along by giving the suggestions and advice as they show the need for it. It is advisable to give the molder doing this class of work some additional pay, preferably in the form of a bonus, over and above his regular earnings.

Frequently in the small piece-work shops, the only attention to training new help, is to put the applicant in with a group of experienced molders, and let him sink or swim, giving him the regular piece-work prices for what good castings he might turn out. This method is not only wasteful of effort, and discouraging to the beginner, but seldom results in the man making good. On the other hand, records are in existence of inexperienced men starting in on a particular job, and in two or three weeks, with the proper attention from their foreman, find themselves turning out as many good castings as men who have been making the same casting for two or three years.

Several questions confront one in connection with the subject of training molders.

(a) Who should be encouraged to take the necessary training to become skilled molders and specialty men?

(b) For how long should the training period last?

(c) What inducement can be offered?

(d) Should a form of contract be used?

Several sources are available from which to draw material to supply our needs for specialty molders.

Many men engaged in laboring work, gradually pick up considerable knowledge of the work the molders are doing and quite frequently they will ask to be given a chance to learn the trade. These men should be encouraged. As a rule they are married and have homes. This is a further inducement to help them better their condition, because they usually become our most reliable workmen.

If the employment department is functioning properly, young men will be found among the applicants for the rougher forms of labor who will be interested in taking a course of intensive training, in order to increase their earnings later. These young men usually will be found between the ages of 22 and 28 years. They have left school quite early, and have been knocking around from one job to another, without getting anywhere in particular. These young men, if given the proper encouragement, soon become good specialty men, and occasionally develop into all-around molders. Many foundries have been successful in taking in newly arrived immigrants and notwithstanding their handicap of language, rapidly developed them into reasonably good specialty men.

Schools Should Be Visited

For the regular foundry apprentice, willing to serve an apprenticeship that he may become a skilled workman, we have to look to the boy leaving school. It is frequently stated that the boys are not going into foundries. The foundry is not an attractive place, particularly for the boy leaving school. While it is no worse than many other industries, it has not had any romance thrown around it that some other industries have, and, therefore, does not appeal to adventuresome boys. If the practical foundryman interested in this subject will take the matter up with the school authorities in his city, he may find that it is not out of order for him to come before the boys' classes, with an appeal to their imagination, and follow it up with visits of the boys to the foundries.

All classes of molders should be taught certain fundamentals but after that for specialty molders only enough training to allow them safely to enter production work. The length of time required for these men necessarily would be governed by their aptitude for the work. No particular reason exists for holding a specialty apprentice for a definite length of time, regardless of his progress. In the case of the all-around molder apprentice, the requirements are entirely different, and naturally the training would cover a considerable period of time. The difference in the mentality of the apprentice would again apply, and there is no good reason for holding a man back simply to have him fill out his time. A definite period of time should be placed on all classes of training, to obligate the apprentice for a definite period, and to have something definite from which to figure. If the apprentice outstripped the schedule he would only be encouraged by being graduated ahead of time.

It is impossible to lay down an exact rate of remuneration for apprentices which would apply in all jobs and communities. However, the spe-

cialty man will have to receive a higher rate than the general apprentice. In many shops it is customary to start specialty men at a rate about equal to the day rate for laborers. This amount usually approximates their previous earnings, and in this way their interest is held until such time as they can be graduated into production. In other shops where piecework have a day rate about equal to 60 per cent of the average piecework earnings, it is customary to apply this day rate to specialty apprentices. For the general apprentice the rate obviously will not be as high at the start as that of a specialty man. The boy must have enough to allow him a little spending money, providing he has the proper arrangements at home, and in addition, is able to look forward to regular increases in his earnings at stated times. It is often found advisable to have some kind of a bonus arrangement, payable upon completion of the training period.

Other inducements besides, than those in the pay envelope should include a clean, attractive workshop, where everything is in its place, and where a feeling of efficiency and pride will be diffused. The toilet arrangements should be absolutely sanitary and elaborate enough to induce the boy, and other employes, as well, to take some interest in their own appearance. Activities outside the regular working schedule such as athletic training and contests should be encouraged. This will tend to keep up the interest in the institution.

A formal apprentice contract is a matter of indvidual preference on the part of the employer. In all cases a reasonable contract should be entered into whenever an apprentice expresses a desire for it. For the general apprentices, the contract is more important, inasmuch as it covers not only service, but a period of instruction, and the contract should cover the whole labor relation. A contract and its discussion impresses the seriousness and importance of the training period, and it dignifies the job. It is more or less of a guarantee to the apprentice of what he may expect when he reaches the goal of his endeavors. If entered into with the specialty men over a period of time beyond the training period, it has a steadying effect upon any inclination he may have to jump to another job upon completion of his training period.

All systems of training foundry apprentices have two distinct objectives: the first is to develop skilled and semi-skilled workers to carry on the work in the several branches of foundry trade; the other is to provide proper opportunity for developing future foremen and instructors. Several plans have been tried, combining school and shop work, and in most cases have failed, owing to improper planning, lack of interest, and particularly lack of co-operation with the schools would be through following up the continuation school idea. Under this plan, a limited number of apprentices indentured for a full apprenticeship course in the shop, would attend a continuation school not less than one-half day each week, receiving pay the same as though they were in the shop.

The school usually is operated in connection with the manual arts training course, as carried on in the local public schools. Here the apprentice would be instructed in mechanical drawing, mathematics, etc. During the course, industrial lectures should be given these students by practical foundrymen, dealing not only with the technical side of foundry practice, but also instilling in the minds of the students the great possibilities before them in the foundry industry. In most cases it is from this type of apprentice we will draw our future foremen. One or two technical schools, and a few universities, throughout the country, devote considerable effort to the organization of foundry engineering courses. These schools are interested primarily in providing the training necessary for the higher executives in the foundry industry and, therefore, they are not factors in training molders.

Few foundries are so small that they cannot afford to provide some method of apprenticeship.

If the molding job were as attractive to the boy as banking, or the profession of medicine or law, then we could expect enough recruits, anxious to get into the trade, and they would also find some means or other of learning. We are faced constantly with a shortage of molders; the job is not attractive to the young man; the father does not encourage his son to take up the trade; and finally, the recruits for the foundry in the last 15 years have been largely from the foreign element in the population. Therefore, it is not only the duty of each management to promote the training of apprentices, but it is the duty of every man in the industry to do so.

Finds Boys Capable

By L. W. KLEIN

SHORTAGE of skilled molders in the section where our plant is located induced us to take on molder apprentices. We educate the boys on our own class of work with the result that they are familiar with the names of the parts and the patterns and we find these boys more proficient in this respect than strange molders coming into the shop.

The boys serve a three year apprenticeship and are not taken on until they are 18 years of age. The first year they are placed with experienced molders as assistants, and in that manner, get a good idea of ramming, gating and dressing molds. They then have core work for six months, and then are put back at molding by themselves until their apprenticeship is finished.

In addition to this training, we enroll them as students in the International Correspondence School, Scranton, Pa., paying part of their tuition, leaving some of the tuition fee to the parents so that they will also take the proper interest in the boy. Monthly reports regarding their progress are received from the school, and the ratings of each boy are sent to me. If the reports do not show favorably the boy is called to account.

The correspondence course includes, arithmetic, reading working drawings, green sand molding, coremaking, machine molding, dry sand and loam work, foundry appliances, foundry chemistry, cupola practice, making cast iron, malleable casting, steel casting, brass and alloy founding and general appliances and processes.

We do not favor the idea of employer and apprentice entering into a written apprenticeship agreement. Should an apprentice not have the essentials of making a good molder or should he become disinterested through lack of appreciation of his work, we do not see why the agreement should not be broken.

Development of the molding machine and specialization of labor does not do away with the need for apprentice training. Many small foundries working on a general class of castings of such nature and quantity as to prohibit their manufacture on a machine. It is the duty of all foundrymen to train apprentices to keep a

supply of molders to meet the demand.

We find that a three year apprenticeship enough. On account of not taking a boy until he is 18 years of age and throwing him on his own resources after the three years are up, boys make rapid headway after their apprenticeship terminates.

The cost is so small and with the many schools affording the proper education for apprentices, it is better to enroll the apprentices in such a school, because co-operation with local school authorities would mean a very desirable special training course.

Apply Time Study to Foundry Work

BY J. F. BLANK

FOR various reasons the time study element of modern or so-called scientific management has been very much slower in finding its way into the foundry than into the machine shop. This is probably because the average foundry is run on a looser basis than the average machine shop, which condition is hardly justifiable, especially in foundries doing repetitive work. Of course, molding may be considered an art. It was developed long before the machine came into use and this may be one reason why the old methods have clung to foundrymen to some extent. Again it is a natural trait to tackle the easier job first, and the writer believes it is easier to establish a standard time on a machine operation, or to standardize machine work, which depends more on the machine than on the human element, than it is to establish standard time on most foundry operations where the human element is a large factor and some of the conditions seem practically beyond control. Too much credit cannot be given the machine shop manager for the advancement he has made in this respect and it certainly looks as if the time will soon come when those foundries which insist upon guessing at the time required, and costs on various jobs, will find themselves in an embarrassing position.

Become Prejudiced

It is unfortunate for those foundries that have attempted to apply time study and have become prejudiced against it because they employed one who set himself up as an efficient engineer, and who in reality was not qualified for, or entitled to, such a position. Under such conditions we can hardly expect favorable results, chiefly because the so-called efficiency engineer did not understand the fundamental elements, or basis, of time study thoroughly and was, therefore, not capable of educating the supervising force, which is absolutely essential. In other cases the reputable engineer with machine shop experience has not obtained satisfactory results. This has probably been due to the fact that he either did not appreciate conditions as they exist in most foundries keenly enough to enlighten the foremen to the extent that they would co-operate with him, or he was not familiar enough with the work to arrive at a standard time without a rate setter, in other words, he did not know which movement could be eliminated and which was absolutely essential. Therefore, it looks as if the real benefits that are to be derived from applying time study are to be had when the foundryman applies it for himself. By this it is not meant that the foundry superintendent or foreman should attempt to make time studies, but that they should be made by some one thoroughly familiar with foundry practice and who also fully understands the elementary principles of time study.

Co-operation Needed

Co-operation by the supervisory force is absolutely essential and this can only be obtained when this force has confidence in those elements of time study which are being applied. Even after it is applied disturbing factors may turn up, and whether these are a result of applying time study or not, the foremen usually debit them against time study. At this point the part which the foremen think is wrong must be carefully straightened out in their minds. If the foremen are enlightened every time they get the wrong impression and encouraged so that they keep applying time study, at the end of six months or more the results will be marked.

The time element is being applied in the foundry daily by those in charge, but many do not realize they are using it. When the superintendent or foreman sets a piece work price he considers how many pieces can be done per day or per hour, and when he estimates his equipment requirements he takes into consideration the number of flasks, etc., required per day, thus using a time unit. He goes even further for he considers how long it will require to dispose of a ladle of iron and get the ladle back to the cupola again and so, from this estimate, he arrives at the number of ladles required. So in practically everything we plan we bring the element of time and it usually is an important factor.

An old maxim states that a thing worth doing is worth doing right, and this maxim certainly applies to the accurate application of the time element. Now there are many ways in which time can be measured correctly, or perhaps we might better say, in which the operations, movements, jobs, etc., can be measured in time units. The method which seems the most practical and perhaps the cheapest, is the decimal stop watch in the hands of some one who can record or make an analytic or elementary time study and observation.

This will give a quite accurate record of all the movements entering into the particular proposition under consideration and likewise the time required in performing each. This method is a big improvement over any person's estimate of the time taken, or previous production records, for we know from experience that many unnecessary movements have existed for years and likewise sometimes movements necessary to produce a high quality product have been omitted.

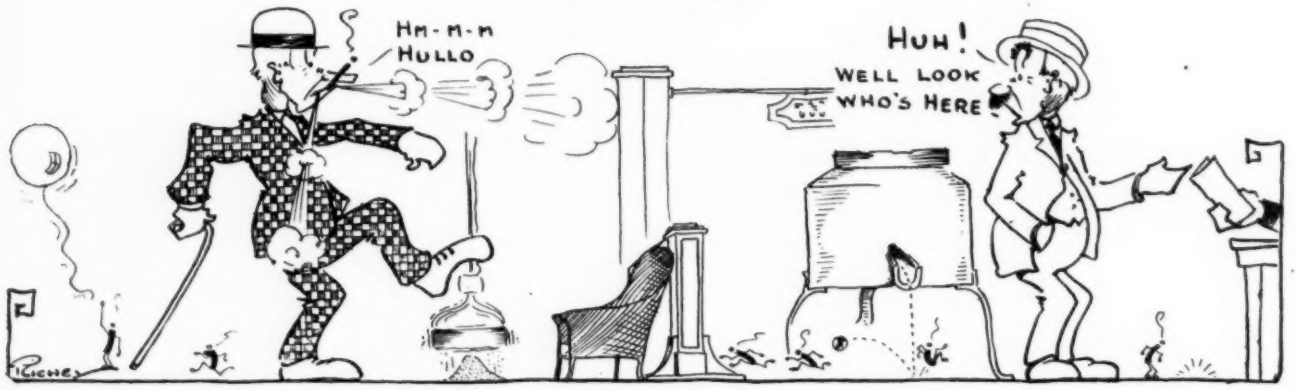
The time will soon come, if it is not already here, when foundries will not be able to afford to pay for unnecessary movements, or in other words, to waste human and mechanical energy. Nor will they be able to afford unnecessary equipment, but will have to apply time study or some other efficient method that will eliminate the waste movements and that will route the equipment so that only the smallest amount necessary to handle the work will be purchased. This will necessitate that the floor and operation lay-outs be made so that the whole shop can be operated at the highest attainable point of efficiency.

Appointed Representative

H. S. Vrooman, who has been in the molding sand business at Chicago the past 30 years, has been appointed representative of the Garden City Sand Co., Chamber of Commerce building, Chicago, to handle its Wisconsin business. His office will be in the Hotel Wisconsin, Milwaukee. Mr. Vrooman began his work in molding sand with the Garden City Sand Co. and later was in business for himself, now returning to his first connection.

Bill Has a Word on Cupola Practice--IV

BY PAT DWYER



WHILE slowly strolling down the main gangway in the Cleveland public hall one day during the recent exhibition staged by the American Foundrymen's association, I met Bill coming in the opposite direction. He was not traveling at anything like his usual speed and therefore, experienced no trouble in coming to a complete stop when I hailed him. In honor of the occasion and also probably in deference to the sensibilities of many of the ladies present, he had discarded the old cob pipe in favor of one of those villainous weeds known among the elect as *Pittsburgh Tobics*.

No person reasonably can object to the second half of the title, but I certainly am surprised that the Pittsburgh chamber of commerce has not adopted vigorous measures to preserve the fair name of the city from such a malodorous connection. It is apparent that one of the 100 per cent, red-blooded, go-getters has passed up a golden opportunity to advertise the city—and incidentally himself. Speaking off-hand and without any definite, knowledge of the subject I should say that a fact-finding commission would experience no difficulty in discovering that an ordinance covering the smoke nuisance had been passed at one time in the city, or for that matter by that august assemblage which so conscientiously interprets the will of the people at Harrisburg in the sovereign state of Pennsylvania. From newspaper articles and other reliable sources of information I have gathered that Pittsburgh is affectionately known as the Smokey City. For many years I remained under the impression that the city owed its title to the *tobic* industry and what is more natural than to assume at this date that other readers of our great national press still labor under the same delusion? If a suggestion is in order from an outsider—of course I know it is not and never will be, but that is no reason why I should not suppose it is, just for sake of illustration,—let's see, where was I? Oh! yes, if a suggestion is in order, I should say that a fact finding commission should be appointed forthwith to establish definitely whether the pall of smoke that hangs over Pittsburgh can be traced to the ubiquitous *tobic* or to some cause or causes unknown.

Thus, having successfully vindicated the aims and objects for which it was appointed, the commission could vote itself a unanimous and deeply sincere vote of thanks, have its picture published in the paper where no person would recognize the individual members and then gracefully disband.

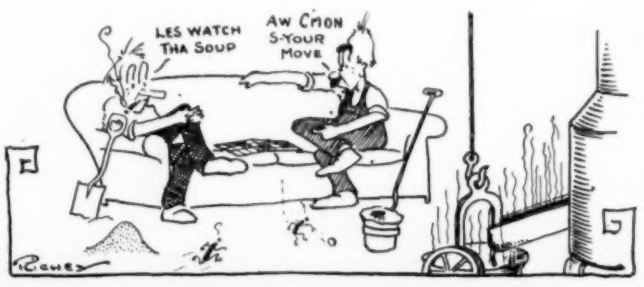
The foregoing, with the exception of the first paragraph readily will be recognized by the experienced reader as a digression. It really adds nothing to the sum total of human knowledge either on the subject of *tobics*—usually referred to as *stogies* by those who never have been obliged to wash their faces or change their collars three times a day—or any other subject. Let's get going m'lads or we won't get the job rammed up today.

Bill wore the *tobic* cocked at a genteel angle in the near or eastern corner of his mouth: but just to show his versatility and familiarity with this style of joss stick, occasionally he rolled it across to the opposite or western corner. Personally, I have no objection to a man who performs this feat neatly and in a workmanlike manner maybe once and certainly not more than three times during the progress of an ordinary conversation. From the man who incessantly rolls it from side to side, good Lord deliver us.

We parked ourselves in one of the numerous rest rooms conveniently located along the midway where, as Bill said: "We can take a few puffs while the big ladle is filling under the spout."

"Some class to this joint," said Bill. "A fellow can sit on a cushioned seat and enjoy a smoke in peace and comfort. Quite a contrast to the time when we had to sneak out to the sand shed behind the old shop for the same purpose. We thought we were so cute and clever and blissfully labored under the delusion that the old man was deceived by the fact that we brought a riddle full of sand back with us. I won't pretend to say that the gaffer was a composition of Solomon, the angel Gabriel and the Three Wise men from the East rolled into one, but later experience has taught me that he knew enough to wink one eye occasionally.

"I have done a little winking on my own account in recent years when the circumstances seemed to warrant and I can't say that it adversely affected production to any noticeable extent. I remember one particularly likable little Scotch molder who made the loam molds for a slag ladle for several years. The outside was bricked up in a pit in the floor and remained intact each time the casting was lifted out. A trifling amount of patching was required on the face and maybe a little blacking now and again. However it was necessary to build a new core



TYPICAL REST ROOM IN A MODERN FOUNDRY

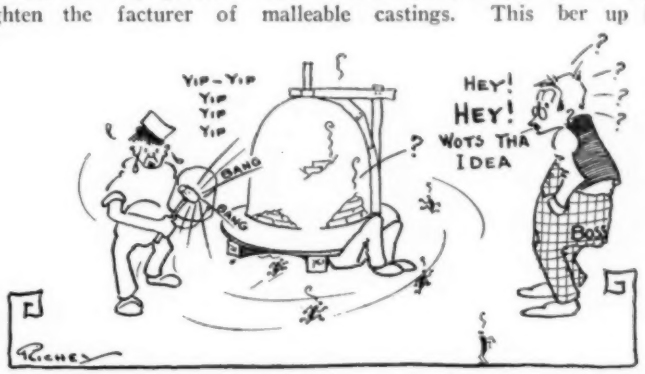
on a cope lifting ring for each casting.

"The core was built on a lifting ring in the usual manner. A plate provided with dabbers served as a crown plate and four long bolts on the inside served to bind the entire core firmly together. Smoking was strictly prohibited, but Sandy was rather short and managed to snatch a few furtive whiffs in comparative security by crouching behind the wall of the core as the building progressed. After the cover plate was set he usually found it necessary to creep inside the core several times a day ostensibly to tighten the bolts. The ring was leveled on blocks above the floor surface and he could crawl in and out quite readily. While Sandy smoked on the inside, his helper on the outside kept vigilant watch for the approach of the enemy, or for any person who reasonably might be assumed to have hostile intentions. If the coast remained clear the helper continued his regular work, mixing loam, sorting out bricks, etc.; but if the enemy appeared in the offing, the faithful retainer rapped on the bottom of a bucket with a hammer ostensibly to remove any loam clinging to the inside, but in reality to warn Sandy to lie low and not come creeping out until the danger of discovery was over. Sandy was an old and valued employe and if he was visible it was not uncommon for some of the high officials to stop and have what Sandy described as *a twee bit crack* on their way past. He smoked a little, old, black, clay pipe and a whiff of his breath as he emerged from under the core would have convicted him in any court in the land."

Influenced by the knowledge that tobies never are sold singly, but always in groups of two or more I interrupted Bill at this point to indicate that if he had a second one on his person I should be glad to accept it and thereby relieve him of the necessity of smoking it.

"Nothing doing," said Bill. "I got this one from a friend a few minutes ago. I ain't mentioning no names and I won't tell you where to find him, but I think I am violating no confidence when I say that he is a noted inventor and further, that he hails from the state of Connecticut.

"Recently he has gone somewhat outside his regular field, that is if an inventor can be said to specialize in such a circumscribed area as an ordinary field. He has devoted considerable time toward the solution of one of the most perplexing problems that confronts the manufacturer of malleable castings. This problem to a greater or less extent is familiar to the manufacturer of any kind of castings, ferrous and nonferrous, but for the time being he is concentrating on the malleable variety. When he has that whipped and eating out of his hand satisfactorily, he is quite confident the solution can be applied to the other metals. I have not had time to give the question serious consideration, but I am free to admit that his proposed plan sounds plausible.



PROBABLY CONTINUATION OF AN ANCIENT HEATHEN RITE

"He is deeply interested in a study of the mysterious causes of shrinks, cracks, draws and blowholes in castings. He has looked up all the available literature on the subject and is satisfied that no person ever has discovered a satisfactory method for preventing these flaws. The subject has formed the basis for innumerable papers and discussions and yet today you can walk into any foundry in this country, or any country, and in the scrap castings from the preceding day's heat you will find some that are due to the foregoing causes.

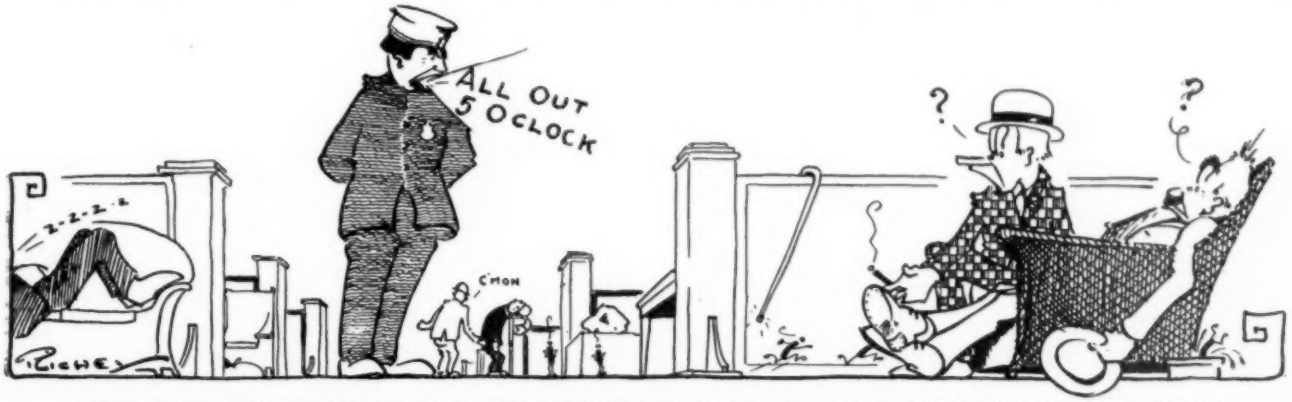
"Our hero, with his usual impetuosity has decided that all former investigators have been following false trails, will-o'-the-wisps and all that sort of thing and he is satisfied that he has hit on the true solution. He has not completely finished his investigations, but from the work already accomplished he feels safe in promising to present a paper on the subject at the next meeting of the Ananias club of which he is a member up in that dear old nutmeg state.

"Briefly, he proposes to place a number of decoys at strategic points in each mold to attract these various defects before they arrive at the surface of the mold and become incorporated in the casting at points where the customer will be sure to see them. He has made a thorough study of the Freudian theory in its relation both to animate and inanimate objects and feels quite certain that if he can classify these various defects according to their sex, the remainder of the problem will present no difficulty.

" 'The method of application,' " to quote his own words " 'will depend to a great extent on local conditions, the state of the weather and the relative position of Sirius the dog star, but I am quite certain I am on the right trail and eventually expect to revolutionize the casting industry.' "

"I told him," continued Bill, "that I was glad to see he had the courage to break away from precedent and tradition and was conducting experiments along original lines.

"The great trouble with many men is that they hate to reason a thing out for themselves. Because a predecessor carried on some operation in a certain manner is considered sufficient reason for continuing the practice indefinitely. The fact that materials and conditions change from time to time is not taken



CARES THAT INFEST THE DAY SHALL FOLD THEIR TENTS LIKE THE ARABS AND SILENTLY STEAL AWAY

into consideration. In other words, there is a tendency to observe the superficial features of the process while at the same time no attempt is made to understand the underlying principles. This is particularly true in connection with the processes employed in melting metals and now that we have a few minutes to spare I see no reason why I should not take up a few further phases of the subject with particular application to the cupola furnace.

"This most widely distributed of all melting mediums usually is referred to as the *kubiller* or the *kueb'lo* and while it is spelled cupola, I can truthfully say I have yet to hear any person pronounce it as spelled. Some day when I have time I may look into this problem or, simpler still, I shall send a questionnaire to all the cupola makers and request an explanation. In the meantime as our mutual friend Mr. Shakespeare says: 'A rose by any other name smells as sweet' and certainly the manner in which a cupola is operated exerts a greater influence on the speed of melting and the quality of the iron than the manner in which the word is pronounced.

"The whole process of melting iron rapidly and economically hinges on three main factors. The first is supplying the maximum amount or volume of air to consume a given amount of coke in a definite time. The next requires proportioning the charges so that each layer of iron is melted by the time the underlying layer of coke is consumed and thus maintain the melting zone at the same point throughout the duration of the heat. The third requires providing a suitable quantity of some fluxing agent that will create a liquid slag that can be drawn off steadily thus leaving the cupola clean.

"Where these three conditions obtain, melting iron is a pleasure, but where any one is missing, trouble develops soon after the wind goes on and steadily grows worse until the bottom is dropped. The three foregoing factors are variables and any person with a mathematical turn of mind can figure the many possible combinations to which they lend themselves.

"However, instead of taking each combination separately and attempting to show how they produce unsatisfactory melting conditions perhaps it is more to the point to consider the manner in which a cupola should be prepared, charged and operated properly to secure hot, fluid iron from a stack that will melt rapidly and evenly throughout the duration of the heat, whether it is for two hours or ten, and then drop clean, thus reducing the amount of picking and patching necessary to put it in condition for the next day's heat.

"The cupola tender chips away the slight fringe of slag remaining above the tuyere line and then plasters a layer of clay or other suitable daubing material to a thickness of approximately 1 inch over the burned out area at the melting zone. If it is necessary to add more than 1 inch to restore the proper shape of the wall, it is advisable to use either brickbats or split bricks covered with a thin layer of clay to make the face uniform. Where too much clay is employed it does not dry properly before melting commences and is apt to buckle and slip off after the wind goes on. This not only leaves the melting zone unprotected, but the clay mixes with the coke below the area at which melting takes place and hastens the choking of the cupola. It will melt, but will not melt at a high enough temperature to convert it into a liquid that will flow through the slag hole. It remains in a thick, viscous mass and interferes with the flow of air from the tuyeres to the fuel.

"After the bottom doors are propped in place a sand bottom is rammed to a thickness of approximately 4 inches with a slope of about 1 inch to the foot, leading down to the spout. It is not necessary to use new sand or even sand from the molders' heaps for this purpose. The sand remaining from the former bottom, possibly augmented by refuse sand from the gangway, is perfectly satisfactory provided it is neither too wet or too dry. It should approximate the condition of the sand employed for making green sand molds and should be rammed to the same density."

"Bill," I said, "I have no doubt your intentions are of the best, but I did not come here to sit in one place for an hour. I have not seen half the show nor half the people I want to see and therefore with your kind permission I'll be on my way. I have another reason which may or may not appeal to you. When the time comes to depart from this world I don't want any left handed stone cutter chiseling an epitaph to the effect that: *Here lies a poor patient listener. He was talked to death.*"

"Go ahead," said Bill. "You have my blessing and sympathy. Any person who prefers walking around to sitting down is deserving of the first and any person who spends his spare time worrying about the epitaph that eventually will adorn his tombstone, certainly merits the second."

The Skinner Engine Co., Erie, Pa., has bought back the first engine made 50 years ago by the founder of the firm. The engine, of 3-inch horizontal semiportable type, will be re-assembled and placed on exhibition alongside the 1500-horsepower unit of latest design now driving the plant machinery.

Brick Lining at Melting Zone Burns Away

Question: We are having trouble with the fire bricks in our cupola. The lining at the melting zone seems to melt down with the iron and needs replacement about every week. The cupola is lined to 40 inches and we should appreciate any information that would help us get rid of this trouble.

Answer: You do not state the length of time the cupola is in blast. If it runs all day long it is only natural that the melting zone lining should need replacement once a week. If it only runs 1, 2 or even 3 hours a day the melting zone lining should last from 6 months to a year. Your trouble may arise from any one of a combination of causes including: an inferior quality of brick, excessive blast, too much lime, daubing clay not suitable for the purpose, or put on too thick.

Where the brick lining in a cupola operated under ordinary conditions burns out rapidly the cause in the great majority of cases can be traced to the clay employed for daubing the melting zone after each heat. The clay should not exceed an inch in thickness, because otherwise it almost invariably will buckle and slip off at some time during the heat and thus leave the brick work exposed. If it is absolutely necessary to make up over 1-inch in thickness, pieces of split brick or brick bats should be employed. However, if a 1-inch thickness of clay does not outlast the heat, then it is evident that it is not sufficiently refractory in character. We are inclined to the opinion, an opinion supported by many similar instances, that you probably are using a local, sticky clay. If that is the case, the remedy is to mix about 2 buckets of sharp sand with each 10 buckets of clay. The sharp sand increases the refractoriness of the mass and also adds to the porosity. The latter factor prevents the daubing from buckling and falling away from the bricks. The maximum amount of sand should be used and this point only can be determined by experiment.

Expands Capacity

The Chattanooga car and foundry plants of the Lucey Mfg. Co., Chattanooga, Tenn., have been purchased by the Ross-Meehan foundries of the same city. The property includes one large building and two smaller ones together with real estate. The foundry has been idle about two years. For the present the lately acquired property is to be used in the production of gray iron castings. The ultimate plan it is understood, calls for the erection of a modern foundry.

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note book form.

SAFETY CODE FOR FOUNDRY WORKERS

(*Continued from Data Sheet No.* 478)

Rule 411. *Goggles*—When the eyes of employes are liable to injury by dust, flying chips or molten metal, they shall wear suitable safety goggles which shall be provided by the employer.

Rule 412. *Helmets and Hoods*—When engaged in sand blasting by hand apparatus workmen shall wear suitable helmets or hoods which shall be furnished by the employer.

Rule 413. *Protection for Welders*—When engaged in welding or burning operations by means of an oxyacetylene or other gas torch, employes shall wear suitable safety goggles which shall be provided by the employer; when engaged in similar operations by means of an electric arc, employes shall use suitable shields or wear suitable helmets which shall be provided by the employer. In both these operations employes shall wear slow combustion aprons or overalls.

Rule 414. *Respirators*—When the dust arising from cleaning operations is injurious to the health of the cleaners, they shall wear suitable respirators which shall be provided by the employers.

Rule 415. *Shoes and Leggings*—When handling molten metal employes shall wear suitable congress or other approved shoes which shall be furnished by themselves, and, when necessary, shall wear suitable leggings to be provided by the employer.

Section 42. Qualifications and Duties of Female Workers

Rule 420. *Examination*—No female shall be employed in a foundry unless upon examination by a physician it has been determined that she is of normal size, health and weight for her age.

Rule 421. *Effort Allowed*—No female employed in a foundry shall lift any object exceeding 25 pounds in weight unless she uses mechanical means by which her physical effort is limited to 25 pounds.

Rule 422. *Handling Hot Cores*—No female employed in a foundry shall be permitted to handle cores which have a temperature of more than one hundred and ten (110) degrees Fahr

(*Concluded on Data Sheet No.* 480)

SAFETY CODE FOR FOUNDRY WORKERS

(*Concluded from Data Sheet No.* 479)

PART V—SAFETY AND WELFARE

Section 50. Recommendations

Rule 500. *Safety Committees*—Accident prevention should be encouraged by the formation of safety committees among the men. All foremen should take a personal interest in accident prevention and are expected to set an example of carefulness.

Rule 501. *Enforcement of Regulations*—Strict enforcement of workshop regulations is one of the best methods of accident prevention.

Rule 502. *Educational Methods*—Experience has shown that most accidents can be prevented by supplementing mechanical safeguarding by educational methods; therefore, the use of safety meetings, bulletin boards, motion pictures and suggestion boxes should be encouraged.

Rule 503. *Room for Meals*—A room should be provided and kept in sanitary condition for employes' use to eat their meals.

Rule 504. *First Aid Kits*—First aid kits should contain:

1	Tourniquet.
1	Pair nickel-plated scissors.
1	Pair nickel-plated tweezers.
1	Triangular sling.
1	Wire gauze splint.
12	Assorted safety pins.
2	2-ounce tubes burn ointment.
1	2-ounce bottle castor oil.
1	2-ounce bottle 3 per cent alcoholic iodine.
1	2-ounce bottle white wine vinegar.
1	2-ounce bottle 4 per cent aqueous boric acid.
1	2-ounce bottle aromatic spirits of ammonia.
1	2-ounce bottle jamaica ginger or substitute.
3	Paper drinking cups.
10	Applicators.
1	Roll absorbent cotton (1.5 ounces).
1	Piece flannel, 25 x 25 inches.
1	Roll, 3 inches x 10 yards, gauze bandage.
2	Rolls, 2 inches x 5 yards, gauze bandages.
3	Rolls, 1 inch x 5 yards, gauze bandage.
1	Spool, 1 inch x 5 yards, adhesive plaster.
6	Sealed packages, 6 x 36 inches, sterile gauze.
1	Teaspoon.
1	Aluminum cup.
1	Medicine glass.
2	Medicine droppers.
6	Tongue depressors.
12	First aid record cards.

Effects of Hot-Dip Galvanizing

Malleable Shown by Research Not To Be Deteriorated by This Process When Phosphorus and Silicon Are Low—High-Phosphorus Irons Will Be Embrittled by Galvanizing—Details of Experience

By W. P. BEAN

PROBABLY few, if any, of the many serious problems confronting malleable foundries have been more difficult of solution than the question as to why malleable that is ductile, black in fracture, and normal in all respects before galvanizing should, by that process, be rendered brittle, brilliantly crystalline or *white* in fracture, and of low resistance to shock.

This work on the galvanizing of malleable was first undertaken in 1916, and has continued until the present time. We now feel that for all practical purposes we have reached a solution and are glad to be able to offer it in a form that can be readily applied to production processes.

It is impossible to give here a detailed account of the early work done on this

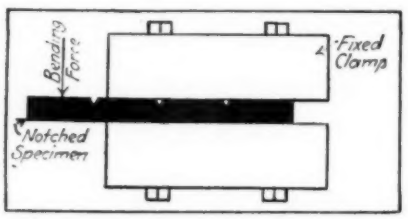


FIG. 1—HOLDING SPECIMEN IN NOTCHED-BAR TEST

problem. As a matter of record we may say that the early work was divided largely into two classes: Investigations of the tendency to deterioration of materials of different compositions; investigations of the method of carrying out the galvanizing process. Work along both of these lines was, to a large extent, carried on simultaneously. Efforts to correlate composition and susceptibility resulted in the vague conclusion that susceptibility of malleable to deterioration seemed to be greater with silicon contents of 1.00 per cent and above.

In so far as the method of carrying out the galvanizing process is concerned, the work tended to show that deterioration was more severe when castings were quenched in cold water immediately after removing from the zinc than if warmer water were used or if time elapsed between removal from zinc and quenching. However, in all of this work the results were far from conclusive and seemed quite inconsistent with such knowledge as we had. It was impossible to predict whether or not a certain iron would withstand the process, and the process could not be modified to such an extent as to eliminate the trouble.

After all this work had been found to be largely futile, it was considered advisable to make a fundamental investigation that would take into consideration every possible factor in the composition and annealing of the iron. This was to be carried out by preparing various sets of alloys, each set having all but one of the chemical elements fixed at a normal value, this one element being varied throughout the entire range that would be encountered in practice. These sets were then to be divided into groups and given various annealing treatments, specimens of all compositions and anneals, however, being subjected finally to one standard galvanizing treatment. In carrying out this plan, only two sets of alloys were prepared, the first being one in which the phosphorus content varies from the lowest possible to an excessive value; the second, a set in which both the silicon and phosphorus contents varied simultaneously, or rather three sets, each containing a different phosphorus content in which the silicon varied over a given range. It was found unnecessary to subject the specimens to more than one kind of anneal for the cause of the deterioration lay in the composition rather than in the annealing treatment.

Methods of Testing

For all of the earlier work on this problem, the tensile test was used as the criterion of quality and deterioration in galvanized material. Frequently, it was noticed that there was relatively slight difference in yield point, ultimate strength, or elongation between the ungalvanized malleable and the same material in the brittle condition after galvanizing. Repeated tests frequently yielded inconsistent results and, in general, it was evident that the tensile test was not sufficiently sensitive for the particular type of deterioration encountered. Therefore, it was obviously necessary to adopt a more sensitive form of test, and to that end a preliminary investigation was conducted on the Charpy tensile impact, Humfrey static notched-bar, and Olsen single-blow impact (Izod) machines. The results of the Charpy test proved to be vague and inconsistent. The Humfrey and Olsen tests were of greater value and, after due consideration, the Humfrey static notched-bar test was adopted and used throughout this research. The Humfrey test has distinct advantages over the single-blow impact machines* and as it measures the ability of a

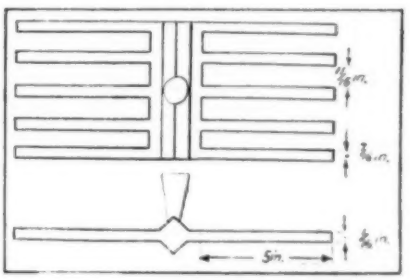


FIG. 2—HUMFREY SPECIMENS WERE CAST 10 ON A GATE

material to withstand slow bending it is an excellent means of detecting galvanizing brittleness in malleable. The test specimens are machined to size and notched with a standard, round-bottom V notch. One end is rigidly gripped in a vise while a bending force is applied to the other end by a series of levers and springs, somewhat as indicated in Fig. 1.

An ingenious device attached to the machine gave an autographic record

*Recent Researches on Static Notched-bar Test, H. Holz. *Chemical and Metallurgical Engineering*, (1922) 26, 941.

Table I

Treatment No.

1 .....Normal; tested as annealed.
2 .....Galvanized; quenched in water at room temperature.
2a.....Galvanized; quenched in oil at room temperature.
2b.....Galvanized; quenched in oil at 300 degrees Fahr.
2c.....Galvanized; quenched in oil at 450 degrees Fahr.
2d.....Galvanized; quenched in oil at 600 degrees Fahr.
3.....Heated in furnace atmosphere to 850-900 degrees Fahr. and quenched in water at room temperature—no contact with zinc.

The author is research engineer, Eastern Malleable Iron Co., Naugatuck, Conn.

Table II

Chemical Composition of Series P

Specimen No.	Silicon, per cent	Manganese, per cent	Sulphur, per cent	Phosphorus, per cent	Total Carbon, per cent
P1	1.01	0.33	0.057	0.031	2.40
P2	0.91	0.29	0.036	0.051	2.39
P3	0.89	0.29	0.041	0.105	2.48
P4	0.81	0.31	0.043	0.123	2.45
P5	0.89	0.32	0.045	0.154	2.64
P6	0.96	0.23	0.053	0.174	2.44
P7	0.83	0.26	0.038	0.183	2.55
P8	0.88	0.26	0.055	0.228	2.55
P9	0.82	0.23	0.047	0.265	2.49
P10	0.86	0.23	0.075	0.297	2.60
Maximum	1.01	0.33	0.075	....	2.64
Minimum	0.81	0.23	0.036	....	2.39
Average	0.89	0.28	0.049	....	2.50

of the test, in the form of a curve, from which may be read and computed the maximum bending moment, in foot-pounds; the angle at which this occurred, in radians or degrees; the total bending angle, in radians or degrees; and the total energy absorbed in breaking the specimen. A mechanical integrator attached to the machine gives this last quantity directly, in foot pounds. By an inspection of the curve produced by the autographic device the ductile material may be distinguished from the brittle. The data relative to the bending angle are, of course, criteria of ductility, while the data relative to energy absorbed in breaking, i.e., total amount of work done on the specimen, are criteria of the strength of the material. The standard specimen affords material enough for three notches so that three complete sets of values are obtained from one specimen.

Series Ran as Check

As a check on the Humfrey tests, one series of specimens in this research was tested by the Olsen single-blow impact machine. In this test, the specimen (machined and notched) is clamped in a vise with one end extending as a cantilever, and broken by a pendulum hammer. The energy absorbed in breaking the specimen is measured by the amount of swing of the pendulum after the blow has been delivered, i.e., in a manner similar to the Charpy measurement.

As has been stated, both the Humfrey and the Olsen were found more sensitive tests than the ordinary tensile test. Roughly, for a given iron, the deterioration produced by galvanizing and measured by these three methods is as follows:

	Per cent
Tensile, ultimate strength	6-8
Tensile, elongation	15-25
Humfrey static	50-60
Olsen impact	60-70

Previous work had shown that attempting to vary the composition of malleable by ladle additions to the regular furnace iron was both inconvenient and uncertain in results, so it was decided to make up melts on a laboratory scale, using as a base a mixture of American washed metal and steel scrap to which were added the necessary amounts of ferrosilicon, ferromanganese, ferrophosphorus and iron sulphide to bring the composition to the desired analysis. The melts were of approximately 18 pounds each, and the melting was accomplished in graphite crucibles in a No. 3 gas-fired melter's furnace. Standard conditions were worked out and, with a little experience, iron of uniform temperature could be turned out day after day, in a total melting time of 2¼ hours.

The Humfrey specimens were cast, ten specimens to a gate, as indicated in Fig. 2. As cast, the specimens were 7/16-inch square in cross section and 5 inches long. Three such gates could be cast from one heat. Tensile bars and wedges were cast on some of the heats, but as this was not done on all heats these results have been given no weight in this paper. The specimens were annealed in a regular annealing oven, under conditions of standard malleable practice. The pots containing the specimens were located approximately in the middle of the oven.

After annealing, the specimens of each composition were divided into three general groups, one of the groups being further subdivided, and each group or group subdivision was given a definite treatment. This gave rise to a system of treatment numbers, which is summarized in Table I.

The points to be borne in mind are that treatments 1 and 2 are the principal treatments throughout the whole investigation, while treatment 3 and the lettered treatments under 2 are somewhat secondary in importance. The reasons for treatments 1 and 2 are, of course, obvious. The other treatments were included in an attempt to show that the galvanizing deterioration is a thermal effect due to the quenching operation rather than a direct chemical effect due to the pickling, zinc absorption, or any of the other reasons advanced at various times in the past. Treatment 3 in particular was intended to show this, for although the specimens were heated to the temperature encountered in the galvanizing process, there was no actual contact with zinc. As will be seen later, these treatments yielded data of great value in confirming our own theories and in leading us to a much clearer understanding of the fundamental causes of the deterioration.

The galvanizing treatments were carried out in a gas-fired furnace built especially for the purpose. Pyrometric control of the temperature of the zinc was maintained throughout the investigation and the bath at all times was well within the range, 850 to 900 degrees Fahr. Thermometers were used for measuring the temperatures of the various quenching baths.

After treatments the specimens were machined to size, ⅜-inch square in cross

Table III

Series III, Humfrey Static Notched-Bar Test

Specimen Number	Phosphorus per cent	Treatment 1, Normal as Annealed Degrees	Treatment 2, Galvanized and water quenched Degrees	Deterioration, per cent	Treatment 3, Furnace Heated and water quenched Degrees	Deterioration, per cent
P1	0.031	17.2	17.2	0.0	20.1	—16.9
P2	0.051	22.9	22.9	0.0	22.9	0.0
P3	0.105	25.8	28.7	—11.2	27.5	— 6.6
P4	0.123	25.8	22.9	11.2	22.9	11.2
P5	0.154	26.9	25.8	4.1	25.8	4.1
P6	0.174	25.8	22.9	11.2	22.9	11.2
P7	0.183	26.4	25.8	2.3	27.5	— 4.2
P8	0.228	26.9	14.9	44.6	17.2	36.1
P9	0.265	26.9	6.3	76.6	10.3	61.7
P10	0.297	22.9	2.9	87.3	5.2	77.3

INTEGRATOR READINGS (STRENGTH)

		Treatment 1, Normal	Treatment 2, Galvanized and Water Quenched		Treatment 3, Furnace Heated and Water Quenched	
		Foot pounds	Foot pounds	Deterioration, per cent	Foot pounds	Deterioration, per cent
P1	0.031	7.2	6.0	16.7	6.5	9.7
P2	0.051	9.9	9.0	9.1	9.2	7.1
P3	0.105	12.3	12.1	1.6	13.3	— 8.1
P4	0.123	10.7	9.8	8.4	10.0	6.5
P5	0.154	12.2	12.0	1.6	12.1	0.8
P6	0.174	11.4	11.5	— 0.9	10.7	6.1
P7	0.183	14.1	13.4	5.0	13.9	1.4
P8	0.228	12.7	9.3	26.8	8.3	34.6
P9	0.265	13.1	4.1	68.7	6.3	51.9
P10	0.297	9.1	2.1	76.9	3.0	67.0

section, notched, and tested in the Humfrey static notched-bar testing machine. one in which silicon, manganese, sulphur, and total carbon were held approximately constant while phosphorus was varied from 0.03 to 0.30 per cent.

The first series to be studied is the 0.30 per cent. Table II gives the analyses of the heats obtained in this series. All of the heats in any one series are prefixed with characteristic letters; for example, all of the heats in this series are prefixed with the letter *P* and all those in the next series with *SP*, and so on.

The fractures of the specimens after being broken in the Humfrey machine of No. 6 or No. 7 are essentially normal in fracture.

Table III contains the data on total bending angle (ductility) and integrator readings (strength) obtained in the Humfrey test. Throughout this paper, each value given in a table or plotted on a curve is the average of three tests. A high degree of uniformity of test values from the same specimen was formed. Under treatments 2 and 3, the deterioration produced by the treatment is given in percentage values based on the values for the normal material (treatment No. 1) as 100 per cent. Of course, a negative or minus deterioration is obviously no deterioration at all, but rather an improvement over the normal value.

Figs. 3 and 4 show the test values of Table III plotted against phosphorus content. Fig. 3 gives the ductility curves and Fig. 4 the strength curves. The dotted curve in each case plots the normal values of the material as annealed and the full line is the value after galvanizing or furnace heating and quenching. It may be seen that the two curves hold approximately together up to a certain phosphorus content, at which point the curve for the treated and quenched material falls off sharply.

It also may be noted that in this series and in the *H*, *O*, and *B* series, to be discussed later, the low-phosphorus specimens, 0.08 per cent and below, were somewhat inferior in mechanical properties to those immediately above them in the phosphorus range. This may be due to the fact that shrinkage enters into the problem at these low-phosphorus contents and materially weakens the iron. In fact, large shrinkage cracks were observed in several of these low-phosphorus specimens. Fortunately, however, it is not necessary to carry the phosphorus down to such excessively low values in order to avoid galvanizing troubles; therefore, this phase of the matter has no actual significance in the practical application of the results of the investigation.

The curves on the lower halves of each figure are plotted from the percentage deterioration values. These percentage curves

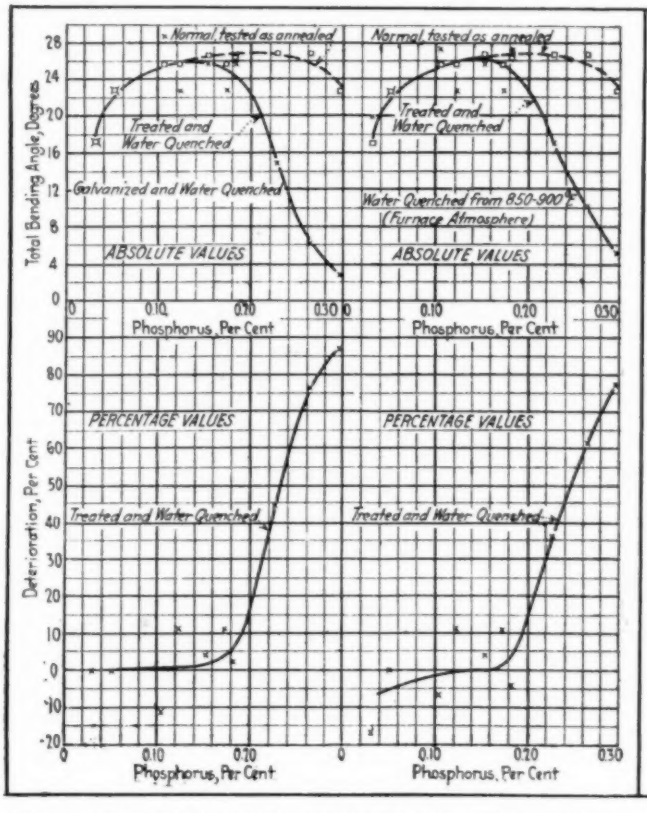


FIG. 3—HUMFREY STATIC NOTCHED-BAR TEST, SERIES P—TOTAL BENDING ANGLE

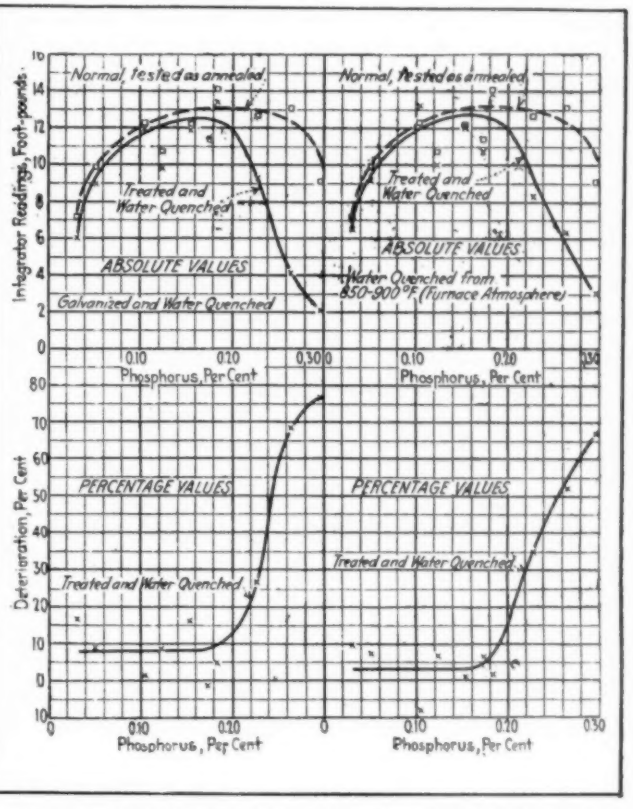


FIG. 4—INTEGRATOR DATA

are shown in Fig. 5. The top row, treatment 1, contains the normal untreated specimens; the middle row, treatment 2, the galvanized water-quenched specimens; and the bottom row, treatment 3, the furnace-heated water-quenched specimens. Phosphorus increases from left to right. It may be noted that the white in the fracture after galvanizing (the middle row) increases with increasing phosphorus and is not evident to any serious extent until the phosphorus has reached approximately 0.15 per cent. The furnace-heated water-quenched specimens (the bottom row) show an exactly similar tendency, except that it is not quite so marked as in the galvanized specimens. The point to be stressed is that all specimens to the left

combine the data of the two upper curves. It must be borne in mind that such curves are a type of inverse curve and that a deterioration is actually represented by a rise. This method of plotting also tends to eliminate variations in test values which might be due to slight differences in chemical composition aside from phosphorus, shrinkage, etc. It may be seen that, just as in the case of the fractures, the curves for the galvanized and furnace-heated materials are exactly similar, the only difference being one of magnitude, and this very small.

To sum up, this series makes it evident that, all other elements being constant, above a certain value phosphorus is a vital factor in producing galvanizing brittleness. It also is evident, from the

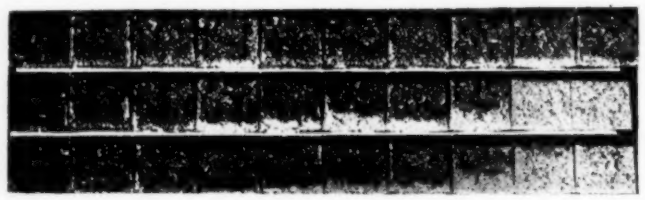


FIG. 5—SECOND PHOSPHORUS SERIES

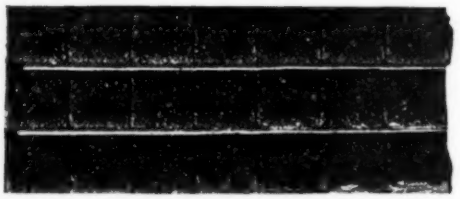


FIG. 6—SILICON-PHOSPHORUS SERIES NO. 1, AVERAGE PER CENT PHOSPHORUS 0.104

furnace-heated series, that the so-called galvanizing brittleness can be induced in the higher phosphorus specimens without any contact with zinc whatsoever.

In the next series to be studied the silicon and phosphorus were varied simultaneously. This was accomplished by taking three series, each of a constant phosphorus content, and varying the silicon over a given range in each. Manganese, sulphur, and total carbon were held as constant as possible throughout. The characteristic prefix of specimen numbers in this series is *SP*. Table IV contains the analyses of the heats in this series and is divided into three sections corresponding to the three constant phosphorus contents. The unnumbered heat in the second section is *P7* from the *P* series, the analysis of this heat permitting the use of its test values in both the *P* and the *SP* series.

White After Galvanizing

The specimens after being tested in the Humfrey machine are shown in Figs. 6, 7, and 8. Each illustration corresponds to one of the constant phosphorus sections of the series, as indicated in Table IV. In each case, the silicon increases from left to right, while the average phosphorus advances from 0.104 per cent in Fig. 6 to 0.189 per cent in Fig. 7 to 0.238 per cent in Fig. 8. It may be noted that the white in the fracture after galvanizing (treatment 2) increases as both the silicon and the phosphorus increase, but that in the lowest phosphorus section all of the specimens showed normal black fractures over the whole silicon range. In the medium phosphorus range, only the lowest silicon irons show normal fracture after galvanizing. In the high phosphorus section, practically all are adversely affected. An almost exact parallelism is evident in the furnace-heated and quenched specimens (treatment 3), bearing out the results of the *P* series, Fig. 3, in a remarkable manner.

Table V contains the data on total bending angle (ductility) and integrator readings (strength) for the specimens of this series as tested in the Humfrey machine.

The data in this table are given in curve form in Figs. 9, 10, and 11, Fig. 9 being the ductility curves and Fig. 10 the strength curves for the galvanized material, while Fig. 11 contains both the ductility and the strength curves for the furnace-heated and quenched material. The dotted curves are the normal values for the heats, tested as annealed (treatment 1). The full-line curves are the values for the treated material. The test data are plotted against the silicon content and a separate set of curves is given for each constant average phosphorus content, i.e., for each section of Tables IV and V. The phosphorus content for each set of curves is marked plainly in the field. The data of this series could, of course, be properly plotted on a three-dimensional diagram, but the difficulty of interpreting such diagrams makes it inadvisable to include one in this paper.

The curves at the top of the figures show little, and in some cases no, deterioration throughout the whole silicon range in this low-phosphorus material (0.104 per cent). The integrator data would seem to be more sensitive in this respect than the total bending angle, although little difference is indicated in most cases. Points that are extremely low and off the curves, particularly the second and third points on some of the curves, are known to be due to unsound-

Table IV

Series SP; Compositions

Specimen Number	Silicon, per cent	Manganese, per cent	Sulphur, per cent	Phosphorus per cent	Total Carbon per cent
SP1	0.54	0.25*	0.051*	0.121*	2.51*
SP2	0.58*	0.28	0.044	0.093	2.50
SP3	0.63	0.25	0.045	0.111	2.45
SP4	0.94	0.28	0.053	0.103	2.46
SP5	1.09	0.25	0.049	0.101	2.53
SP6	1.21	0.23	0.051	0.105	2.50
SP7	1.28	0.27	0.049	0.109	2.36
Maximum	...	0.28	0.053	0.111	2.53
Minimum	...	0.23	0.044	0.093	2.36
Average	...	0.26	0.047	0.104	2.47
SP8	0.57	0.26	0.053	0.192	2.47
SP9	0.66	0.23	0.048	0.204	2.54
SP10	0.74	0.26	0.051	0.186	2.46
	0.83	0.26	0.038	0.183	2.55
SP11	0.93	0.27	0.055	0.180	2.45
SP12	1.08	0.29	0.050	0.184	2.49
SP13	1.23	0.31	0.044	0.182	2.42
SP14	1.47	0.27	0.042	0.198	2.49
Maximum	...	0.31	0.055	0.204	2.55
Minimum	...	0.23	0.038	0.180	2.42
Average	...	0.27	0.048	0.189	2.48
SP15	0.65	0.24	0.071	0.230	2.52
SP16	0.84	0.33	0.052	0.239	2.44
SP17	1.00	0.36	0.039	0.227	2.50
SP18	1.36	0.31	0.053	0.259	2.48
Maximum	...	0.36	0.071	0.259	2.52
Minimum	...	0.24	0.039	0.227	2.44
Average	...	0.31	0.054	0.238	2.49

*Figures not included in averages.

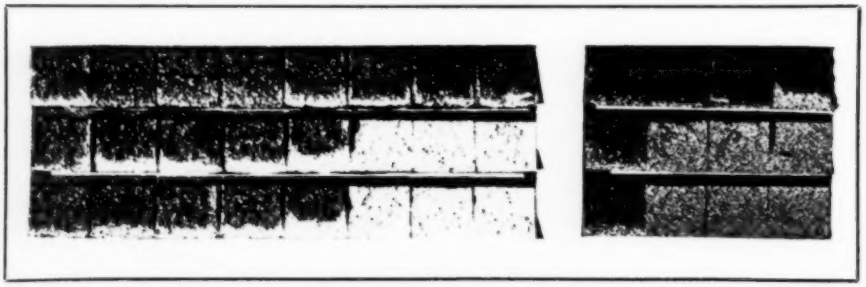


FIG. 7—SILICON-PHOSPHORUS SERIES NO. 2; AVERAGE PER CENT PHOSPHORUS 0.189 FIG. 8—SILICON-PHOSPHORUS SERIES NO. 3; AVERAGE PER CENT PHOSPHORUS 0.238

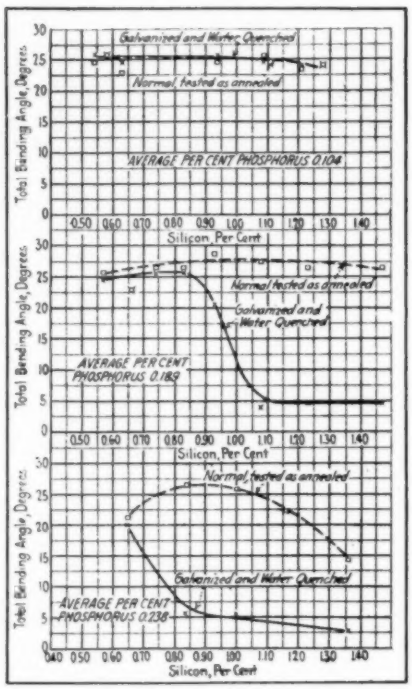

Galvanized and Water Quenched
Normal, tested as annealed
AVERAGE PER CENT PHOSPHORUS 0.104
Total Bending Angle, Degrees
Silicon, Per Cent
AVERAGE PER CENT PHOSPHORUS 0.189
AVERAGE PER CENT PHOSPHORUS 0.238

FIG. 9—HUMFREY STATIC NOTCHED-BAR TEST, SERIES SP; TOTAL BENDING ANGLE

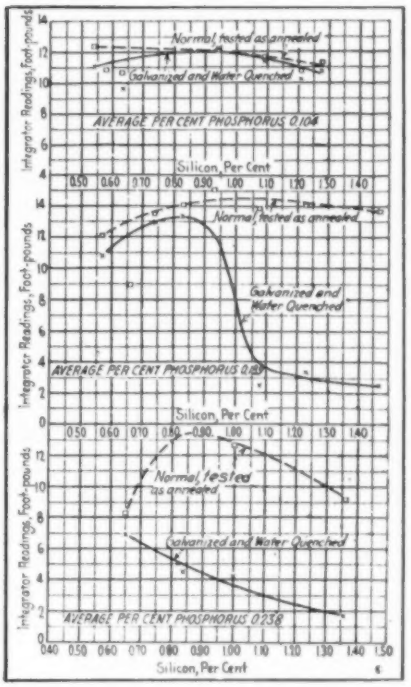

Normal, tested as annealed
Galvanized and Water Quenched
AVERAGE PER CENT PHOSPHORUS 0.104
Integrator Readings, Foot-pounds
Silicon, Per Cent
AVERAGE PER CENT PHOSPHORUS 0.189
AVERAGE PER CENT PHOSPHORUS 0.238

FIG. 10—HUMFREY STATIC NOTCHED-BAR TEST, SERIES SP; INTEGRATOR DATA

ness (shrinkage) in these specimens. For the next higher value of phosphorus (0.189 per cent) the curves indicate that galvanizing has no deleterious effect until approximately 0.80 per cent silicon is reached, above which value the curves for the galvanized material drop off sharply. For the highest value of phosphorus (0.238 per cent), the curves indicate that only the lowest silicon heat withstood the galvanizing process, and even this heat showed some deterioration. A comparison of the curves of Fig. 11 with those of Figs. 9 and 10 shows that the furnace-heated and quenched material acted in a manner exactly similar to the galvanized and quenched material and that, in turn, the test data for both of these treatments bear out the indications of the fractures. To sum up, this series makes it clear that besides the phosphorus, the silicon also plays an important part in producing the deterioration in galvanized malleable. The results on the furnace-heated specimens bear out those of series *P*, indicating that the deterioration is a thermal phenomenon.

Phosphorus Range Varied

The results of both the *P* and the *SP* series are incorporated in a single working curve given in Fig. 16. This curve plots the critical combination of phosphorus and silicon above which galvanizing deterioration may be expected and below which galvanizing can be accomplished with impunity. Reference is made to the curve in the conclusions at the end of this paper, suffice it to say that the foundryman should not attempt to work too closely to this curve but should try to keep well to the low-phosphorus, low-silicon side.

The next series to be studied is similar to the first one discussed, that is, all elements except phosphorus were held constant while that element was varied over a given range. Table VI gives the analyses of the heats in this series.

As specimens from this series were used for three different studies, the series has no single characteristic prefix letter. The series was really divided into three parts; the *H* series, which was treated and tested in the usual manner in the Humfrey machine; the *O* series, which was treated and tested in the Olsen single-blow impact machine; and the *B* series, which was used for the study of hot quenching baths, the specimens being tested in the Humfrey machine.

Table VII gives the data obtained in the Humfrey test on normal and galvanized specimens of this series. Under treatment 2 the deterioration produced by the galvanizing is given in percentage values based on the test values of the normal iron as 100 per cent.

In Fig. 12, test valves have been plotted against the phosphorus content, the ductility curves being on the right, and the strength curves on the left. The dotted-lines curves show the values for the normal material as annealed; the full-lines, the values for the galvanized material. As in previous curves of this type, the test values for the normal and galvanized materials are practically identical up to a certain value of phosphorus, above which galvanized material deteriorates rapidly with increasing phosphorus. The lower curves on Fig. 12 give the same data in the inverse, or percentage, form. All these curves are exactly similar to those shown in Figs. 4 and 5; this furnishes an excellent check on the work, as the data for the curves of Figs. 4 and 5 were obtained from an entirely different set of heats from those of Fig. 12 (see Tables II and VI).

Test by Impact

Table VII gives the data obtained when specimens of these same heats were tested in the Olsen impact machine. In Fig. 13 are the test values plotted against the phosphorus content. The dotted line

Table V

Series SP; Humfrey Static Notched-Bar Test

Specimen Number	Silicon, per cent	Average per cent phosphorus	Total Bending Angle (Ductility): Treatment 1 Normal as Annealed, degrees	Total Bending Angle (Ductility): Treatment 2 Galvanized and Water Quenched, degrees	Total Bending Angle (Ductility): Treatment 3 Furnace Heated and Water Quenched, degrees.	Integrator Readings (Strength): Treatment 1 Normal Annealed, foot pounds	Integrator Readings (Strength): Treatment 2 Galvanized and Quenched, foot pounds	Integrator Readings (Strength): Treatment 3 Furnace Heated and Quenched, Water, foot pounds
SP1....	0.54	....	24.6	25.8	24.6	12.4	11.1	10.2
SP2....	0.38	....	25.8	25.8	24.6	10.9	11.1	10.7
SP3....	0.63	....	22.9	24.6	24.1	10.7	9.6	8.3
SP4....	0.94	0.104	24.6	25.8	25.8	12.1	12.2	11.1
SP5....	1.09	....	25.8	24.6	25.8	11.7	11.4	11.0
SP6....	1.21	....	23.5	24.1	24.1	10.8	10.2	10.5
SP7....	1.28	....	24.1	24.1	23.5	11.3	10.7	10.2
SP8....	0.57	....	25.8	24.6	26.4	12.1	10.8	11.4
SP9....	0.66	....	22.9	22.9	17.8	8.9	9.0	7.6
SP10...	0.74	....	26.4	25.8	25.8	13.5	13.0	12.9
	0.83	....	26.4	25.8	27.5	14.1	13.4	13.9
SP11...	0.93	0.189	28.7	20.6	17.2	15.1	12.3	12.2
SP12...	1.08	....	27.5	4.0	4.6	13.9	2.5	2.8
SP13...	1.23	....	26.4	4.6	4.0	14.1	3.3	2.6
SP14...	1.47	....	26.4	4.6	3.4	13.7	2.5	2.2
SP15...	0.65	....	21.2	20.2	17.8	8.3	6.9	6.8
SP16...	0.84	....	26.4	5.7	6.3	13.8	4.5	4.1
SP17...	1.00	0.238	25.8	5.7	4.6	12.7	4.2	3.6
SP18...	1.36	....	14.3	2.9	2.3	9.2	1.7	1.5

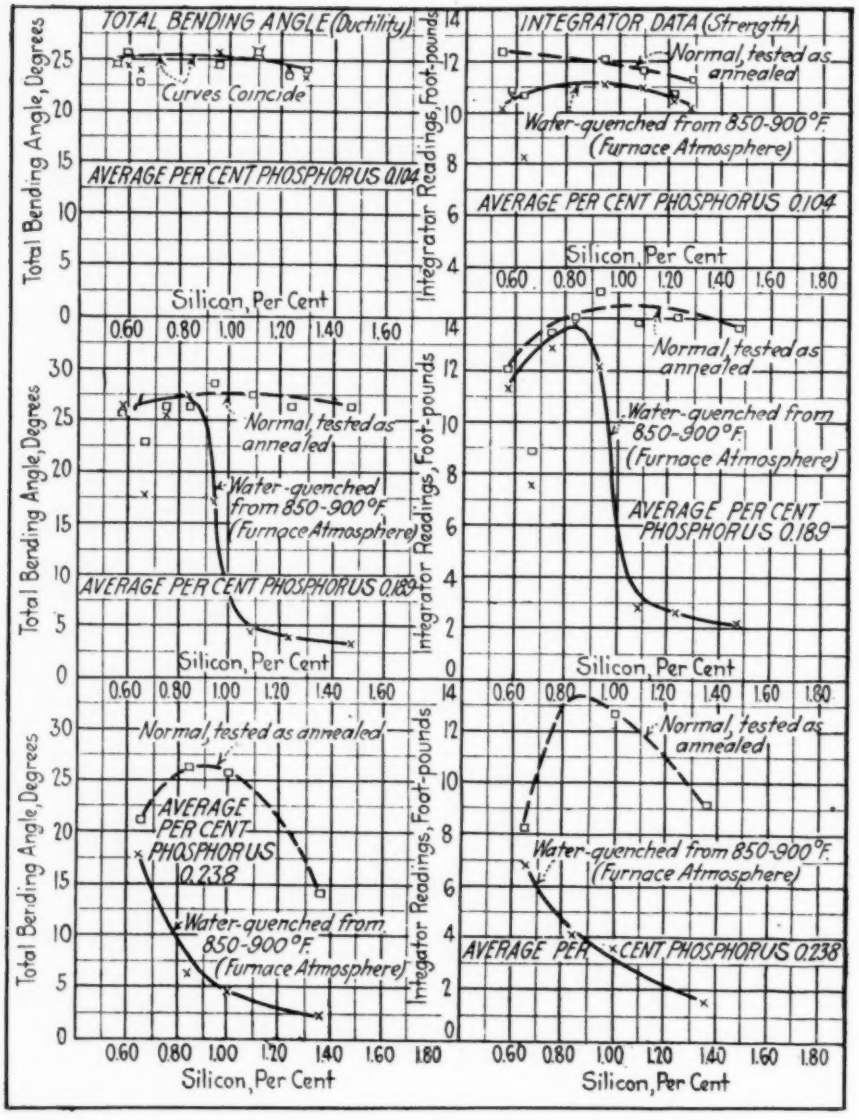


FIG. 11—HUMFREY STATIC NOTCHED-BAR TEST SERIES SP

gives the values for the normal ungalvanized material; the full line gives the values for the galvanized specimens. The curves would seem to indicate that a slight embrittlement is caused by galvanizing, as soon as the phosphorus has exceeded 0.07 per cent and this brittleness increases rapidly with higher phosphorus contents. The lower curve gives the data in percentage form, the dot-and-dash line being the lower left-hand curve of the *H* series, Fig. 12, reproduced for direct comparison between the Olsen impact and the Humfrey static tests. The indications are that the Olsen impact is a more sensitive test; in fact, a probably supersensitive test so far as this type of deterioration is concerned. It is interesting to note that the Olsen curves have the same general shape as the corresponding Humfrey curves and hence serve as a check on the validity of the method of testing adopted.

In this series a number of specimens, the analyses of which are given in Table VI, were divided into six groups and treated, as in Table I under treatments 1, 2, 2*a*, 2*b*, 2*c*, and 2*d*. These hot quenching-bath treatments were given in an attempt to show that the galvanizing deterioration could be eliminated by reducing the severity or suddenness of the quench; i.e., by bringing the temperature of the quenching bath nearer to that of the zinc bath. The quenching media used in these experiments were lubricating oils of high flash point; the specimens after being quenched were allowed to cool in the air.

Table IX gives the data obtained when these specimens were tested in the Humfrey machine. Fig 14 gives the ductility data and Fig. 15 gives the strength data in curve form. The dotted curve in each case plots the normal untreated test values versus phosphorus content, while the full-line curve plots test values after galvanizing and quenching in one of the several media. The quenching medium and its temperature are plainly marked in the space occupied by each pair of curves. It may be noted that the curves are of the same general shape as all the others of this type in the report.

The galvanized and quenched material is practically as good as the normal material, tested as annealed, for the low values of phosphorus. As the temperature of the quenching bath is increased, the curve for the galvanized and quenched material approaches the normal curve over a greater portion of its length until, with the 600 degrees Fahr. quenching bath, the two curves are close in the case of strength and practically coincident in the case of ductility, indicating that if the quenching could be entirely eliminated there would probably be no embrittlement in galvanizing. It is interesting to note the difference between the curves for the material galvanized and quenched in water, and that galvanized and quenched in cold oil. Both the quenching baths were at ordinary room temperature, yet there is an appreciably smaller deterioration in the oil-quenched specimens. The high-temperature quenching baths caused considerable damage to the zinc coating. For the practical application of this phase of the research more suitable quenching baths would have to be devised and it is problematical if high quality zinc finish could be obtained, even with these, at the higher temperatures.

The results of this investigation have been tried out on a production scale and found to be in entire agreement with the indications of the laboratory work. The problem has been attacked by lowering the phosphorus in regular heats at a number of plants until the irons were well

Table VI

Series H, O, and B; Compositions

Specimen No.	Silicon, per cent	Manganese, per cent	Sulphur, per cent	Phosphorus, per cent	Total Carbon, per cent
H, O, B 10	0.92	0.25	0.063	0.039	2.51
H, O, B 20	0.92	0.21	0.052	0.071	2.55
H, O, B 30	0.85	0.22	0.049	0.114	2.48
H, O, B 43	0.86	0.24	0.051	0.168	2.52
H, O, B 44	0.96	0.23	0.053	0.174	2.44
H, O, B 53	0.88	0.26	0.055	0.228	2.55
H, O, B 63	0.82	0.23	0.047	0.265	2.49
H, O, B 62	0.91	0.24	0.053	0.291	2.51
H, O, B 80	0.85	0.23	0.065	0.372	2.50
Maximum	0.96	0.26	0.065	....	2.55
Minimum	0.82	0.21	0.047	....	2.44
Average	0.89	0.23	0.054	....	2.51

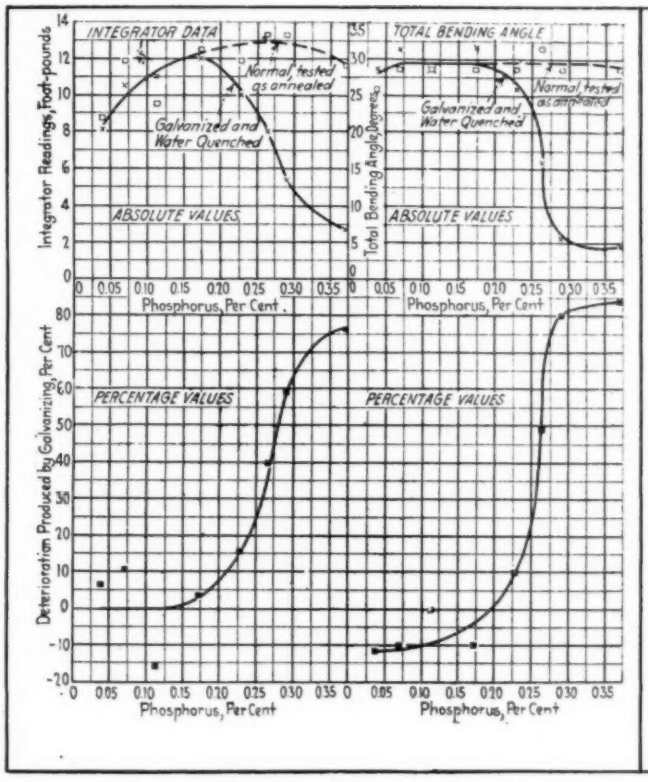


FIG. 12—HUMFREY STATIC NOTCHED-BAR TEST, SERIES H

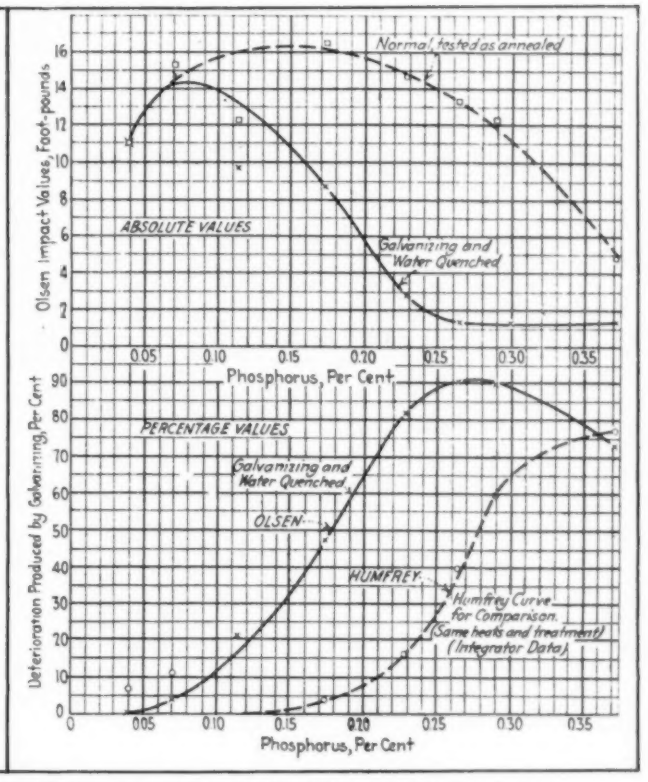


FIG. 13—OLSEN IMPACT TEST, SERIES O

within the lower field of the working diagram, Fig. 16. Samples of iron from these heats, when given a commercial galvanizing treatment, have maintained all the properties of normal untreated material, i.e., excellent bending properties and normal black fracture. A close study of the fluidity of the molten iron, as measured by the percentage of good castings, during the period in which the phosphorus was being lowered in the heats has shown that this property is not adversely affected, at least to any serious extent. It has also been evident that the ordinary tensile properties of the product have not been adversely affected by the lowered phosphorus: in a word, this lower phosphorus malleable is as good as, if not better than, the old higher phosphorus material and, in addition, can be sold as proof against galvanizing brittleness.

Data from a previous investigation on the purely metallographic side of this

*H. S. Rawdon, *Chemical and Metallurgical Engineering*, (1920) 22, 508.

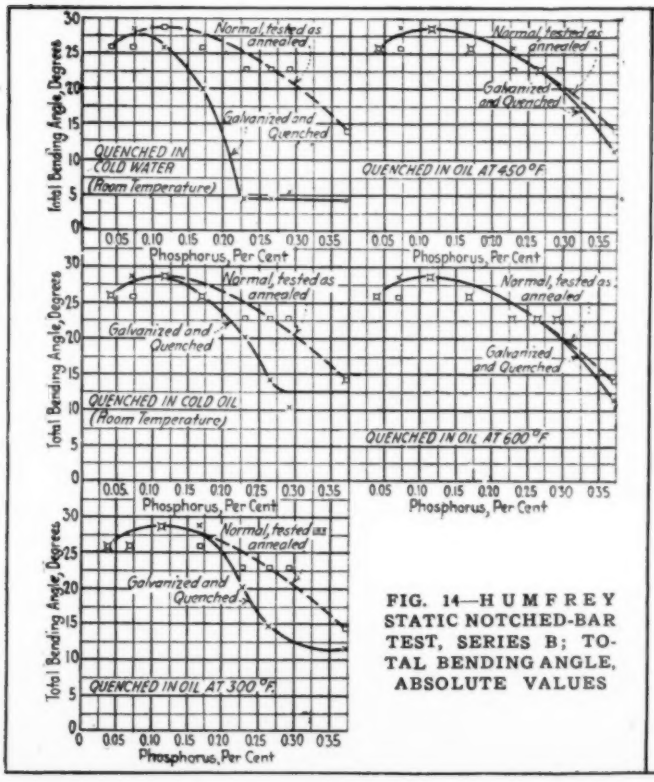

Total Bending Angle, Degrees
Normal, tested as annealed
Galvanized and Quenched
QUENCHED IN COLD WATER (Room Temperature)
QUENCHED IN OIL AT 450°F.
QUENCHED IN COLD OIL (Room Temperature)
QUENCHED IN OIL AT 600°F.
QUENCHED IN OIL AT 300°F.
Phosphorus, Per Cent

FIG. 14—HUMFREY STATIC NOTCHED-BAR TEST, SERIES B; TOTAL BENDING ANGLE, ABSOLUTE VALUES

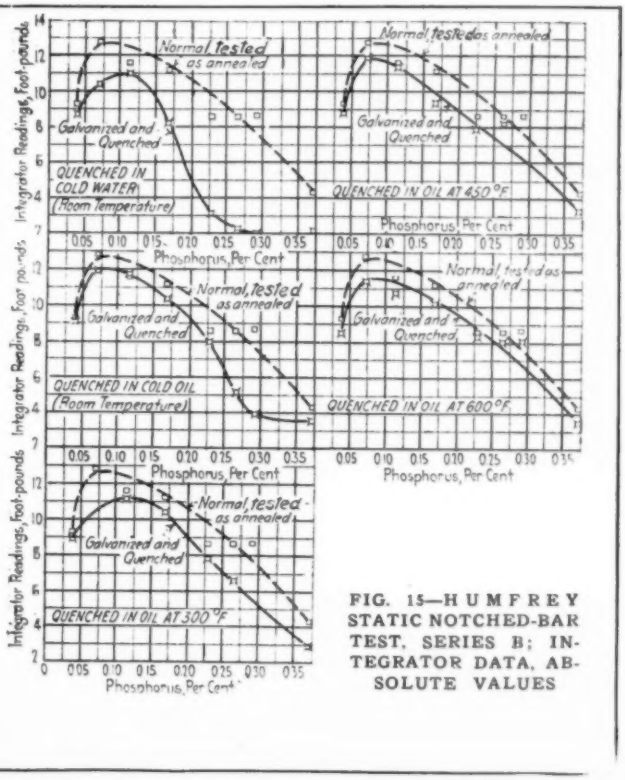

Integrator Readings, Foot-pounds
Normal, tested as annealed
Galvanized and Quenched
QUENCHED IN COLD WATER (Room Temperature)
QUENCHED IN OIL AT 450°F.
QUENCHED IN COLD OIL (Room Temperature)
QUENCHED IN OIL AT 600°F.
QUENCHED IN OIL AT 300°F.
Phosphorus, Per Cent

FIG. 15—HUMFREY STATIC NOTCHED-BAR TEST, SERIES B; INTEGRATOR DATA, ABSOLUTE VALUES

Table VII

Series H; Humfrey Notched-Bar Test

Specimen Number	Phosphorus per cent	Treatment 1, Normal as Annealed, degrees	Galvanized and Water-quenched, degrees	Per cent deterioration	Treatment 1, Normal as Annealed, pounds	Galvanized and Water-quenched, foot pounds	Per cent Deterioration
H 10	0.039	25.8	28.7	—11.2	8.7	8.1	6.9
H 20	0.071	28.7	31.5	— 9.8	11.8	10.5	11.0
H 30	0.114	28.7	28.7	0.0	9.5	11.0	—15.8
H 44	0.174	28.7	31.5	— 9.8	12.5	12.0	4.0
H 53	0.228	28.7	25.8	10.1	11.9	10.0	16.0
H 63	0.265	31.5	16.0	49.2	13.3	8.0	39.8
H 62	0.291	28.7	5.7	80.1	13.3	5.4	59.4
H 80	0.372	28.7	4.6	84.0	11.7	2.7	76.9

problem are included in this report. A study of the path of rupture in normal malleable and malleable that had been embrittled by the galvanizing process was made by inducing partial fracture in both types of iron and then examining the incipient fracture under the microscope. Fig. 17 shows the path of rupture in the normal ungalvanized material. The fracture is transgranular, i.e., across the ferrite grains, and is entirely in accord with the behavior of normal metals at ordinary temperatures.* It is interesting to note how the fracture travels from one temper carbon spot to another. Fig. 18 shows the path of rupture in brittle, galvanized material. The fracture is intergranular, i.e., around ferrite grains, or in the grain boundaries rather than across the grains, a condition always found to be associated with metals broken at high temperatures, or with abnormal material broken at ordinary temperatures.

Fractures Studied

References in the literature bearing on the plastic deformation of malleable furnish additional evidence on this phase of the work. A study* of the structures on the compression and tension sides of a bar of malleable distorted by transverse bending yielded evidence that on the tension side, deformation takes place in a transgranular manner, as in Fig. 17, while on the compression side deformation takes place in an intergranular manner, as in Fig. 18. As is well known, the compression side of bent malleable is frequently white in fracture. We are thus in possession of independent data confirming our conclusion that malleable which is brittle and white in fracture after galvanizing ruptures in an intergranular manner. Further work along these lines is in progress, in which we will attempt to determine just what is at the basis of this intergranular brittleness and how it can be correlated with the phosphorus, silicon and quenching factors.

The results of this investigation may be summed up as follows:

It has been shown that the deterioration of malleable in the hot-dip galvanizing process is intimately connected with the phosphorus and silicon content of the iron. In general, low-phosphorus, low-silicon irons will withstand the process best and show practically no deterioration. With phosphorus contents of about 0.10 per cent, the silicon may go as high as 1.20 per cent without serious trouble from galvanizing. High-phosphorus, high-silicon irons are practically certain to deteriorate and be embrittled by galvanizing.

A working curve has been given in Fig. 16, which differentiates between irons liable and not liable to deterioration, so far as silicon and phosphorus are concerned. This curve should serve as a ready guide to the foundryman in determining whether or not a given iron is fit for galvanizing. However, it should be borne in mind that the curve is only an approximation, and that to be absolutely safe, the foundryman should keep to the left of it by at least 0.02 per cent to 0.03 per cent phosphorus. As time goes

*H. A. Schwartz: American Malleable Cast Iron, chapter 7; *Iron Trade Review*, (1921) 68, 902.

Table IX

Series B; Humfrey Static Notched-Bar Test

TOTAL BENDING ANGLE (DUCTILITY)

Specimen Number	Phosphorus, per cent	Treatment 1, Normal as Annealed, degrees	Treatment 2, Galvanized and Water Quenched, degrees	Treatment 2a, Galvanized and Quenched in Cold Oil, degrees	Treatment 2b, Galvanized and Quenched in Oil at 300 degrees Fahr., degrees	Treatment 2c, Galvanized and Quenched in Oil at 450 degrees Fahr., degrees	Treatment 2d, Galvanized and Quenched in Oil at 600 degrees Fahr., degrees
B 10	0.039	25.8	25.8	25.8	25.8	25.8	25.8
B 20	0.071	25.8	28.7	28.7	...	28.7	28.7
B 30	0.114	28.7	25.8	28.7	28.7	28.7	28.7
B 43	0.168	25.8	20.1	25.8	28.7	25.8	25.8
B 53	0.228	22.9	4.6	20.1	20.1	25.8	22.9
B 63	0.265	22.9	4.6	14.3	14.9	22.9	22.9
B 62	0.291	22.9	5.7	10.3	...	...	22.9
B 80	0.372	14.3	4.6	14.3	11.5	11.5	11.5

INTEGRATOR READINGS (STRENGTH)

Specimen Number	Phosphorus, per cent	Treatment 1, Normal as Annealed, foot pounds	Treatment 2, Galvanized and Water Quenched, foot pounds	Treatment 2a, Galvanized and Quenched in Cold Oil, foot pounds	Treatment 2b, Galvanized and Quenched in Oil at 300 degrees Fahr., foot pounds	Treatment 2c, Galvanized and Quenched in Oil at 450 degrees Fahr., foot pounds	Treatment 2d, Galvanized and Quenched in Oil at 600 degrees Fahr., foot pounds
B 10	0.039	9.3	8.7	9.1	8.9	8.8	8.5
B 20	0.071	12.8	10.4	11.9	...	11.9	11.4
B 30	0.114	11.6	11.0	11.7	11.1	11.3	10.7
B 43	0.168	11.2	8.2	10.4	10.4	9.4	10.1
B 53	0.228	8.6	3.2	8.0	7.8	7.9	8.3
B 63	0.265	8.6	2.3	5.2	6.6	8.2	8.0
B 62	0.291	8.7	2.0	3.9	...	...	8.1
B 80	0.372	4.3	2.2	3.6	2.9	3.3	3.5

Table VIII

Series O; Olsen Single-Blow Impact Test (Izod)

Specimen Number	Phosphorus, per cent	Treatment 1, Normal as Annealed, foot pounds	Treatment 2, Galvanized and Water-quenched, foot pounds	Per Cent Deterioration
10	0.039	11.0	11.0	0.0
20	0.071	15.3	14.7	3.9
30	0.114	12.3	9.7	21.1
44	0.174	16.5	8.7	47.3
53	0.228	14.7	2.7	81.6
63	0.265	13.3	1.3	90.2
62	0.291	12.3	1.3	89.4
80	0.372	4.8	1.3	72.9

on figures from actual practice will fix the position of this curve more definitely.

It has been shown that in those irons that are embrittled, the deterioration by the galvanizing is due to a thermal effect resulting from the quenching after the galvanizing operation. Below a certain combination of phosphorus and silicon contents, this effect is not evident or at least is negligible; above it, the effect becomes marked as indicated by Fig. 16. The exact mechanism of the deterioration, i.e., whether it is a species of internal strain, or a segregation of the silicon and phosphorus in some way at the grain boundaries, is not as yet known.

It is evident that galvanizing embrittlement may be avoided by manipulation of the phosphorus and silicon, by the use of high-temperature quenching baths (300 to 600 degrees Fahr.) after galvanizing, or by eliminating quenching entirely. The first is the most practical method and the easiest of accomplishment, as it can be carried out in the foundry and does not involve a modification of the galvanizing process itself.

Tests Are Varied

Micrographic evidence has been submitted tending to demonstrate that fracture in the defective galvanized material is intergranular, an abnormal condition, while fracture in ungalvanized material is transgranular, a condition normal to nearly all metals at room temperatures. In other words, the brittleness of such malleables as deteriorate in galvanizing is due to intergranular weakness.

A test that involves a slow bending stress is an excellent measure of the quality of malleable and a sensitive detector of embrittlement or other form of deterioration. The single-blow cantilever impact test is sensitive to such deterioration in malleable but does not furnish as much information as the static bending test. Both tests are superior to the ordinary tensile test as a measure of the quality of malleable.

The means for eliminating galvanizing brittleness developed in this investigation have been found to be practicable from a production standpoint.

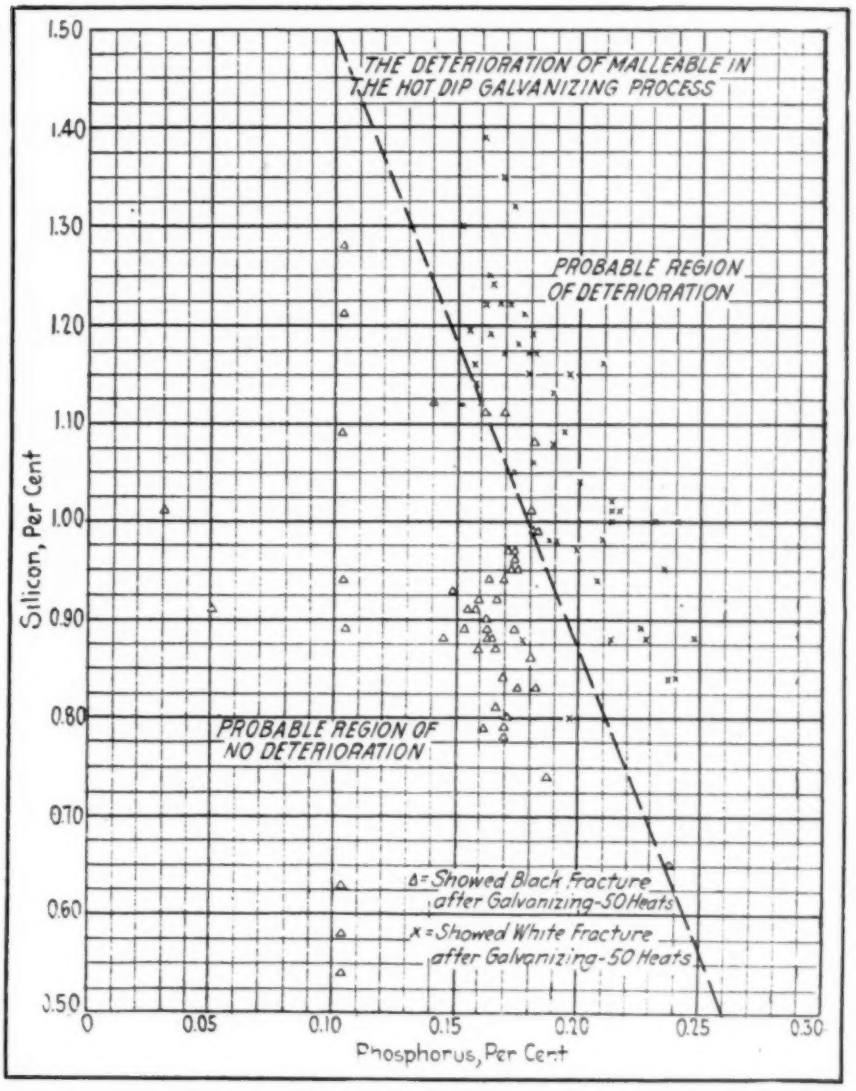


FIG. 16—RESULTS OF INVESTIGATION TRIED OUT ON A PRODUCTION SCALE

Start Gray Iron Foundry

The Lincoln Foundry Co. has been organized by former employes and officers of the American Brakeshoe & Foundry Co., and a foundry established at Laporte, Ind., for the production of gray iron and semisteel castings. A. R. Manderson is president, George H. Rolinson, vice president, Thos. F. Lewis, treasurer and A. F. Golick, chemist and metallurgist. The foundry taken over by this company has a capacity of 30 to 50 tons per day.

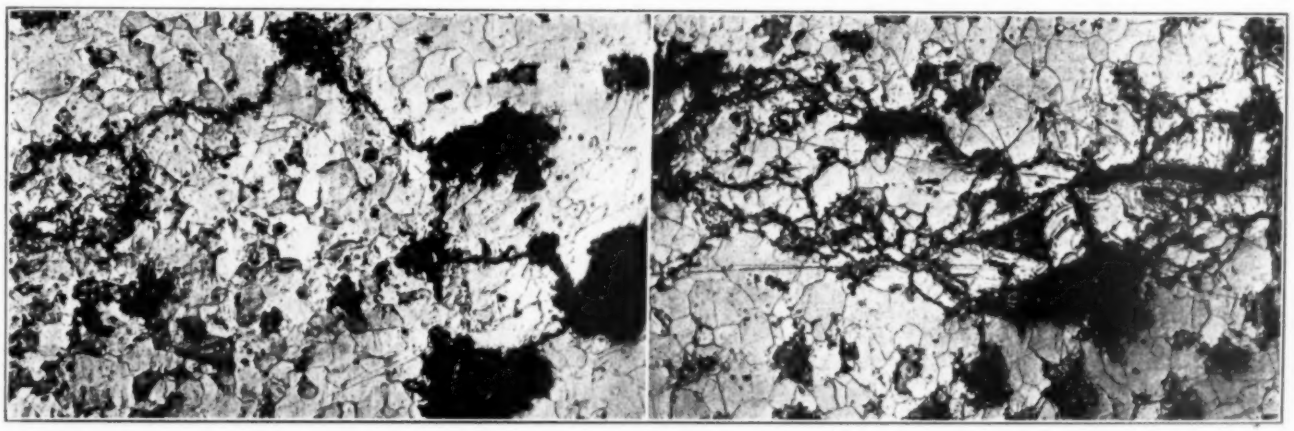


FIG. 17—TRANSCRYSTALLINE RUPTURE IN GALVANIZED MALLEABLE—X 100 DIA. FIG. 18—INTERCRYSTALLINE RUPTURE IN GALVANIZED MALLEABLE—X 100 DIA.

Correcting Flaws in Metal Mixtures

Problems of the Gray Iron, Malleable and Steel Foundry Discussed

By H. E. Diller

Not Practical to Cast Vacuum Chamber

Question—I would like to know whether it would be possible to make an automobile piston with a vacuum chamber in the head, across the entire section of the piston?

Answer—We do not believe a piston could be made out of cast iron with a vacuum chamber inside the piston head. To do this the chamber would first have to be cored with an opening left to remove the sand. A vacuum would then have to be produced in the chamber and the hole sealed before air could get into the chamber. Then the problem would be to get an iron which would be dense enough to prevent even a very slow leakage of air.

Chill Increases Life of Plow Shares

Question—We wish to improve the wearing quality of our plow shares. The shares are cast from pig iron of the following analysis:

	Per Cent
Silicon	2.00 to 2.50
Manganese	1.25 to 1.50
Phosphorus	0.30 to 0.35
Sulphur	0.03 to 0.035

All the shares are chilled on the edges to make them wear longer. However, we find that the points and edges of some of the shares last for a long time while others wear on the point and edges with a couple of months' continuous plowing. We would like to know what should be the composition of iron to make the plow shares take a deep chill and at the same time be soft and tough near the bolt holes and upper parts. Will the quality improve by the addition of 10 per cent of steel scrap in the cupola?

Answer—We would judge from what you say that the plows which wear out quickly are not chilled deeply. In this case the silicon in your casting should be lower. In America, plow manufacturers run the silicon in the metal in their plow points around 1 per cent. Approximately 35 per cent of scrap from the mixture and 10 per cent steel scrap are used with the pig iron to form the charge. The pig iron is placed on top of the coke, then the scrap iron and on top of this the steel scrap. The steel addition strengthens the metal but does not increase the hardness of the chilled portion. Lower silicon will, of course, harden your iron somewhat, but you will, no doubt, be able to drill it. If you do not have a chemist at your works, you can determine the proper mixture by breaking a few of the castings and examining the depth of chill and the structure in the gray portions.

Burns too Much Carbon Out of Iron

Question—I am using a mixture of 50 per cent pig iron and 50 per cent hard-iron scrap in the air furnace for making malleable iron, but cannot get the total carbon in the finished metal up to 2.50 per cent.

Answer—It is evident that your low carbon in the malleable is due to oxidation. It may be that you are having too sharp a flame from your overhead blast. If you are using 50 per cent pig and 50 per cent hard-iron scrap, you should be able to get your carbon up to 2.50 per cent without difficulty. It would be well to study how the air comes into the furnace to see whether the heated air comes more in contact with the metal than it does with the vapor of the flame. Ordinarily, silicon burns out of iron before carbon but at unusually high temperatures carbon will burn first. The action in your furnace could be checked by determining the per cent of silicon and carbon lost during the melt and between the time the metal is melted and the last ladle poured.

Cupola Loss Heavy Using Light Steel

Question—We are working the converter process and using 30 per cent pig iron and 70 per cent steel scrap in the cupola. The steel scrap consists of short rail ends and the general run of melting scrap known as *melting steel*. We would like to know whether we could melt successfully in the cupola what is known as *bundled steel* scrap and also *hydraulic compressed* scrap. Bundled steel scrap would be black sheet steel pieces ranging from ⅛ inch thick to as thick as No. 16 and 18 gage. Hydraulic compressed would be sheet steel clippings ranging from 20 to 28 gage. Some of this material would be black and some would be tinned. This grade of scrap would cost $5 a ton less than the scrap we are now using. Any information you can give as to what troubles we would encounter in blowing the metal in the converter would be appreciated.

Answer—It would be possible to melt a small proportion of bundled steel scrap or hydraulic compressed scrap in the cupola, but we do not think it would be advisable to use as much as 70 per cent of this material in the charge. The difficulty with this scrap is that it is in such thin sections it would be subject to excessive oxidation. In this way a large percentage of the metal would be lost and the heavy slag which would result might cause trouble in the cupola operation. If you start with a small proportion of bundled scrap and gradually increase, you can determine how much you can handle by the way the cupola operates and by the percentage of loss. This probably will be too high to warrant the use of more than a small proportion of this grade of scrap. The metal secured in the ladle would give you no trouble in the converter if indications show that the cupola has operated properly without an excess of slag.

Make Cupola Malleable

Question—Can malleable iron be made in the cupola; and if so, what should the mixture be?

Answer—Malleable iron is made regularly in a cupola by some firms. For this purpose a mixture composed of approximately 50 per cent pig iron and 50 per cent hard iron from the same mixture is used. The composition of the finished casting should be approximately 0.9 per cent silicon, below 0.2 per cent phosphorus and 0.2 to 0.3 per cent manganese. Sulphur varies widely under different conditions and sometimes goes as high as 0.25 per cent. This iron is annealed in the same way as malleable iron made in the air furnace except that a slightly longer time and higher temperature is required. The silicon in this mixture being so low, it will be necessary to use plenty of coke in the cupola to get the iron up to the required temperature. Some malleable foundries use a ratio of 7 to 1, not including the bed.

Cleaning Steel Castings—II

Consideration of the Proper Layout for a Cleaning Room Serves to Promote Efficiency and to Lessen Handling Costs—Types of Grinding Wheels

By H. R. SIMONDS

LABOR required to clean steel castings varies from 15 to 60 per cent of the total required to produce the castings from the raw material. In a previous article, appearing in the May 1 issue, the author treats of the general phases of the cleaning problem. He shows how the total costs may be reduced through proper gates and heads. The methods of removing these necessary excess part, are detailed and particular instructions are given for using the oxy-acetylene or oxyhydrogen torch. In the present article, Mr. Simonds lays stress on proper plant layout or design in relation to cleaning room efficiency. He advises that the cleaning work be divided, the light castings being taken to one part of the cleaning floor while those of heavier section are diverted to another portion. Trucks and suitable boxes are valuable aids in handling the pieces to be cleaned. Two typical layouts, which are suggested by those whose experience covers many such installations, are suggested. These show the arrangement of grinding and snagging wheels in relation to each other, to the other cleaning room equipment and to the annealing ovens. Certain definite classifications are possible by which the type of grinder, that is to say, bench, floor, swing or portable grinding machines may be chosen. Castings weighing under 2 pounds commonly are ground on bench stands. Those ranging from 2 to 150 pounds may be handled on floor stand grinders. Castings weighing over 150 pounds commonly are ground by swing frame grinders. A succeeding article which will appear in an early issue will give the methods by which the proper types and grades of grinding wheels may be selected.—Editor.

STEEL castings after they have been poured are handled in a regular sequence of operations. These, briefly are as follows: Flogging or knocking off sand and some gates; sand blasting or tumbling in the case of small castings; cutting off risers and gates; welding; annealing; chipping and grinding or both, sand blasting or tumbling; finally, inspecting, packing and shipping. From this it may be judged that grinding or snagging as it usually is called, when the process is for the purpose of cleaning rough castings, is a relatively unimportant part in the production of castings. In some cases snagging is not important and often it does not even appear as a separate operation. In the foundry usually when the chief consideration is the actual removal of metal, usually it is cheaper to chip. However the surface left after chipping is rough and unworkmanlike and so it is often the practice, even when metal is removed with a chipping hammer afterward to smooth off the surfaces with snagging wheels. Hard alloy steel castings are difficult to machine and for this reason they are often ground to desired dimension rather than machined. However, in this case, the grinding operation falls outside of the general scope of snagging and so will not be considered here.

The term *grinding* and *snagging* are not definitely separated in ordinary foundry practice, but generally grinding is to dimension and, therefore, more accurate than snagging which consists of merely removing rough places or excess metal. In foundry development, the use of grinding wheels for snagging castings has been slow of adoption and even now has not gained a position which its many advantages warrant. Foundrymen have not kept close account of costs and often have been alarmed by the rapidity with which the wheels wear down without going further and finding out the tonnage in castings which the wheels have handled. Snagging machines too often have been treated as auxiliary or emergency equipment and it is only within comparatively recent years that the design of snagging departments in connection with a foundry has

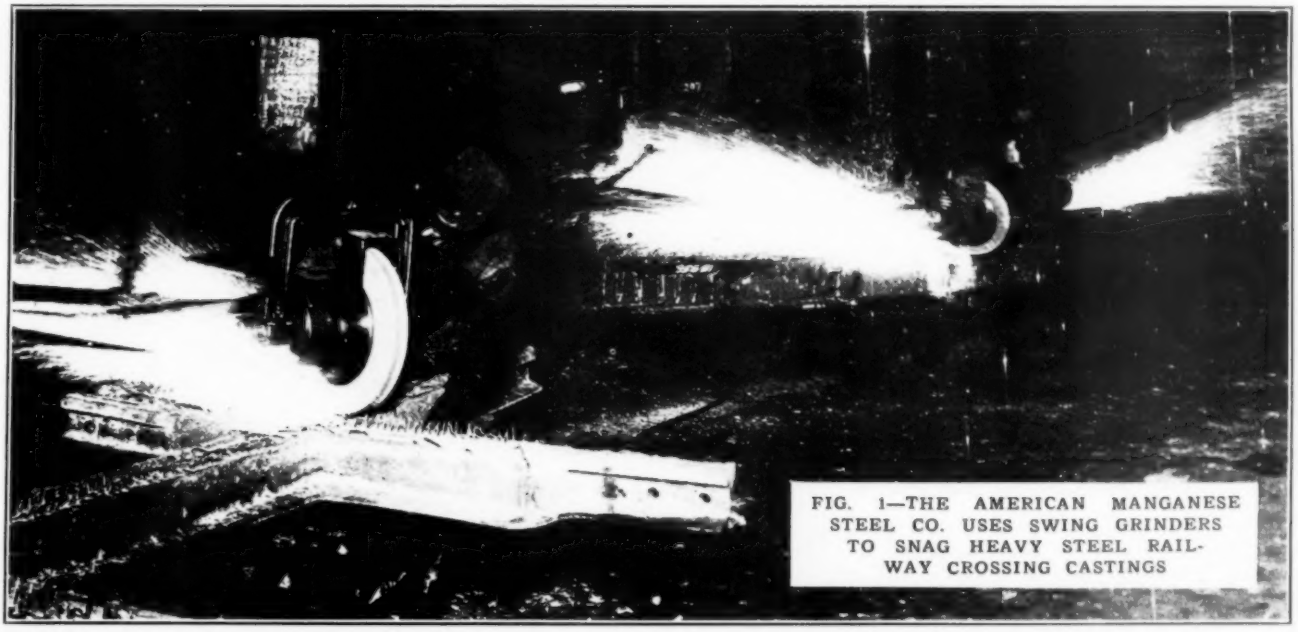


FIG. 1—THE AMERICAN MANGANESE STEEL CO. USES SWING GRINDERS TO SNAG HEAVY STEEL RAILWAY CROSSING CASTINGS

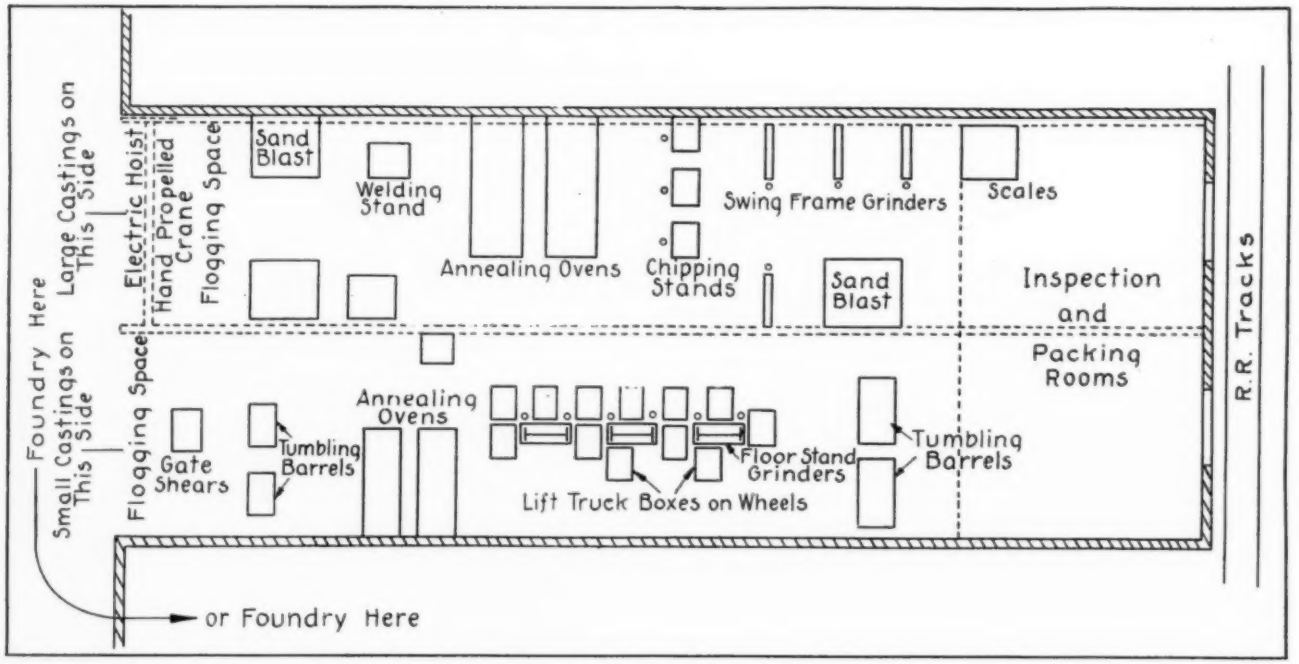


FIG. 2—AN IMPORTANT CONSIDERATION IN LAYOUT IS TO ASSURE THAT CASTINGS FOLLOW THROUGH THE CLEANING ROOM IN REGULAR SEQUENCE

been given serious and studied attention.

Snagging is so intimately connected with the other cleaning operations that it will be well here to consider the design of the entire cleaning department. Figs. 2 and 3 show two typical layouts for cleaning rooms in steel foundries. The plan in Fig. 2 provides for large castings on one side and small castings on the other. On the large castings side, a small electric hoist and hand propelled crane facilitates handling work. On the other side, it is planned to have transportation by electric lift truck in conjunction with proper boxes. This means that the floor should be paved with wood block or other suitable material for the smooth operation of trucks. The foundry, as indicated, is to be either at the left or in the foreground and the flow of material is straight through the cleaning room to the inspection and packing rooms at the right hand end.

The scheme in Fig. 3 is to have castings all enter at a central doorway, the light castings being diverted to the right hand side of the room and the heavy castings to the left. In this case, the heavy castings are handled by a monorail system, but electric lift trucks still are suggested for handling the light castings. Details of arrangement of apparatus necessarily must be dependent upon the size and shape of castings. Heavy castings which cannot be handled easily by two men require swing frame grinders and if the number of heavy castings is large in proportion to

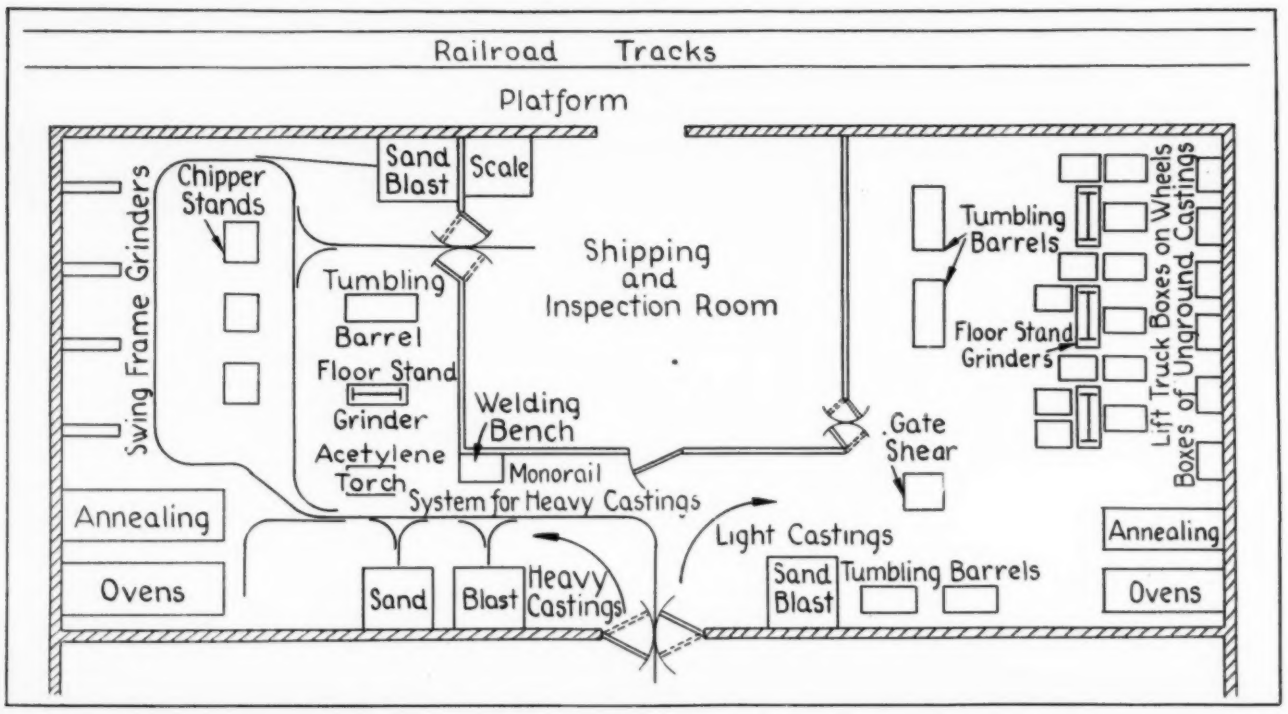


FIG. 3—CASTINGS SHOULD BE SEPARATED ACCORDING TO WEIGHT AND ROUTED TO THE MACHINES DESIGNED TO CLEAN THEM, WITHOUT CROSS HANDLING

the light castings, the equipment shown on the left of Fig. 3 should be increased and that shown on the right decreased. One of the chief features of both of the designs shown is the separation of light castings from heavy castings. This means duplication of annealing ovens and of some other equipment, but has proved so great an advantage in many foundries through the reduction in handling charges, that it is deemed advisable wherever a plant product covers a considerable range in size of castings. The arrangement of machines shown is the result of a great deal of study to develop the most efficient handling methods. The time required to transport the castings from one point of operation to the next has been reduced as far as possible by proper spacing of apparatus on the assumption of a flow of various sized pieces through the department. Often time is lost in snagging through picking up and carrying castings to grinding wheels and then carrying and depositing the ground castings in another place. On small casting work the lift truck in combination with storage trays or boxes has been found to be most satisfactory.

In Fig. 3 a typical arrangement of floor-stand grinders is shown. Each stand has two grinding wheels and two operators. The incoming castings are brought by the trucks to the machines in trays which are elevated as high as possible from the floor without incuring danger of their tipping when being transported. These trays then form storage tables which are moved in as close as possible to the machine and thus reduce the handling to a minimum. Other similar trays are placed on the opposite side of the machine to take on castings which have been ground. In the plan, a space for storage of unground castings is left along the wall. This has been criticized on the ground that it removes the floor-stand grinders further from the windows and thus cuts down some of the light. Undoubtedly this would be a feature worth considering in a relatively dark room, but in this plan ample light throughout the plant is assumed and the storage of unground castings is shown at a point which is both out of the way and convenient to the annealing ovens and the floor-stand grinders.

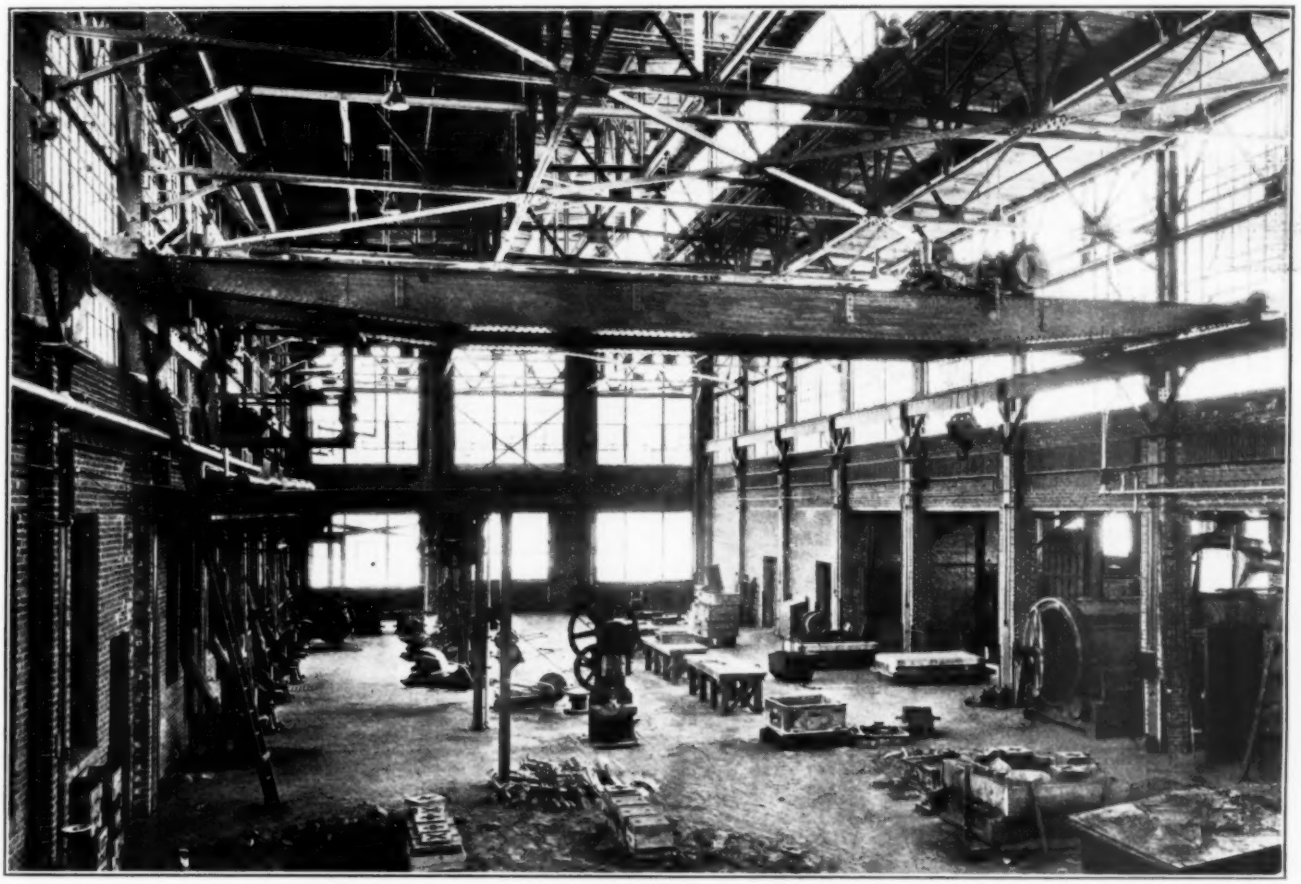


FIG. 4—GROUPING OF GRINDING MACHINES, PROPER FACILITIES SUCH AS CRANES, LIFT TRUCKS AND GRINDING STANDS PROMOTE EFFICIENCY IN CLEANING OPERATIONS

Factors That Govern

In general, the chief considerations in the design of a cleaning department are; first, to arrange the different tools and machines in approximately the same order as the normal sequence of operation; and second, to provide room between machines and ample light. Finally it is necessary to provide a good means of transportation. Stands may be arranged along the wall upon solid benches. Floor stands are best arranged in a line at a sufficient distance from any wheel or other machine so that the boxes of castings can be fed to them from one side and taken away at the other. When lift trucks are not used for transporting castings, wheeled boxes serve the purpose. A good box for the floor-stand castings is one about 3 feet x 4 feet, mounted at the center upon two 12-inch diameter wheels, and having 3-inch castor wheels at each corner. Such boxes, if properly made, may be pulled about by a plant tractor.

Fig. 4 shows the cleaning department in a steel foundry which has just been completed in Massachusetts. Here the molding and pouring floors occupy about three-fourths of a long, well-lighted building. The cleaning department occupies the remaining fourth of the floor area at one end in the illustration. A row of floor-stands extends along the left side of the room and in front of these is

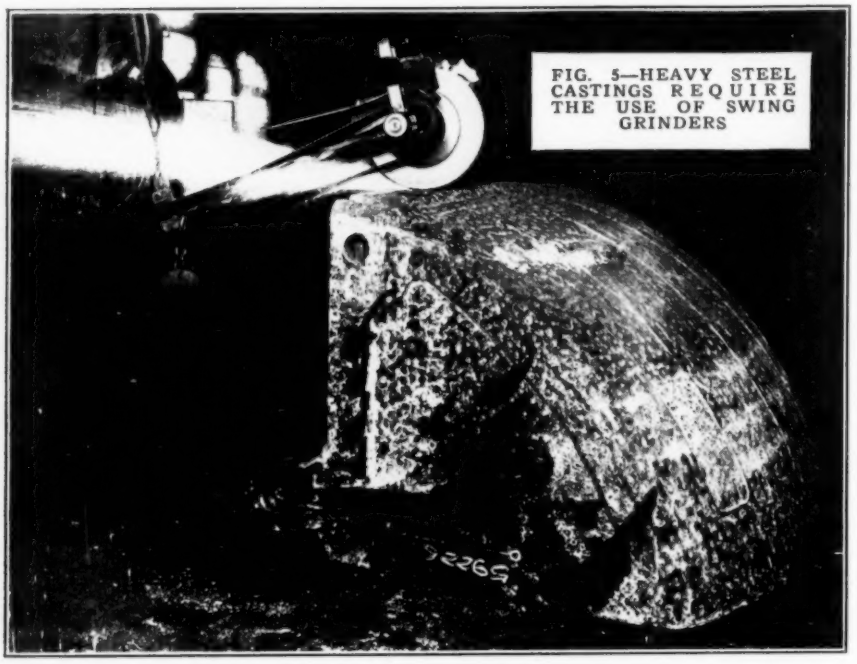


FIG. 5—HEAVY STEEL CASTINGS REQUIRE THE USE OF SWING GRINDERS

a row of electrically driven swing framed snagging machines, each machine having a 15-horsepower motor mounted so as to balance the weight of the grinding wheel which it drives by a short belt. Each machine is pivot supported, so that it has practically universal movement. In the center of the floor is seen a sprue cutter and to the right of this is a space for chipping and cutting. Further to the right are the annealing ovens and the sand-blasting equipment. Material in this plant is handled by the 5-ton crane shown and also by hand operated cranes which are located at various points.

When the cleaning department has been laid out, the next step is the purchase of equipment. The design and operation of grinding machines has an important bearing on the work performed and these will be discussed later.

Eliminate Vibration

Having determined the wheel characteristics according to suggestions which will be given in a succeeding article, some attention should be given to the machines on which the wheels are to be used. And their set up in the cleaning room. According to the nature of the work, these may be grouped under four classifications. These are bench stands, floor stands, swing frame grinders and portable grinding machines.

Floor stands are most generally used in foundries. These consist of a solid frame supporting the grinding wheel at a convenient height above the floor. These have the advantage over bench stands of being more rigid and more accessible. Floor stands may be conveniently arranged as previously described, so that material is brought in at one side and taken away at the other. The chief consideration in floor stands is to have a firm foundation, concrete if possible, extending down to rock or hardpan in the ideal case. Of course this is impracticable where the grinding room is on the second floor or above. A good foundation makes a big difference in the efficient use of grinding wheels by eliminating vibration.

Floor stands usually are arranged with two wheels on a single shaft, belt driven from the center. When this is the case, care should be taken not to have the wheels too close together which might cause interference when two heavy castings were being ground at the same time. A popular type of machine used in foundries has a distance of about 5½ feet between wheels. It always is advisable in installing new equipment to provide for two or three special pulleys so that the speed may be changed to compensate for wearing down or to correct inefficient surface speed. Spindles holding wheels on a double wheel stand should have right and left threads so that the process of grinding tends to tighten rather than loosen the holding nuts.

Swing frame grinders are used wherever the work is too large to handle on the floor stand. Usually pieces weighing over 150 pounds are best snagged with swing frame grinders. Fig. 1 shows a typical installation of swing frame grinders in use on rail cross-over castings. These machines hang from a single pivot support, thus giving practically universal motion to the grinding wheel. Fig. 5 is another example where the swing frame grinder is the proper machine to use. In this case, the casting is that of a large clam shell bucket. Portable grinders are used for interior surfaces which can not be reached in any other way and are also used where light grinding is necessary on heavy castings. Because of the limitation in weight of a portable grinder, and therefore in size of grinding wheel, these machines could not be used to advantage on heavy work.

One foundry gives the following classifications for use of different types of machines:

Castings weighing up to 2 pounds are ground on bench stands.

Castings from 2 to 150 pounds are ground on floor stands.

Castings above 150 pounds are ground on swing frame grinders.

Power used for driving grinders is an important consideration. Recent tendency in design is toward individual electric motor. However, portable machines are found using three types; namely, electric, pneumatic and flexible shaft. The advantage of the flexible shaft is chiefly reduced weight of the machine which the operator must handle. In an eastern railway shop where special groove grinding is done on a large scale, an installation of a row of flexible shaft portable grinders is giving excellent results.

The proper selection of grinding wheels, costs and safety precautions for the grinding room will be presented in a following article.

Graphite Sales Increase

The sales of crystalline graphite in 1922 amounted to 1,849,776 pounds, valued at $85,242. This was an increase of 56 per cent in quantity as compared with 1921, according to a statement given out by the United States department of the interior. The average value of the graphite per pound was 4.6 cents in 1922, which was 1.8 cents less than in 1921.

The quantity of amorphous graphite sold was 220 short tons, which was an increase of 19 per cent in comparison with 1921. This quantity represents the sales of only two companies.

The new foundry of Campbell, Wyant & Cannon Foundry Co., Detroit, has been placed in operation at 100 tons daily. It is planned to advance this production to 200 tons daily, as the company has a large contract for castings from the Durant Motor Co. on hand.

Build Large Electric Furnace

Steel Melting Furnace Being Installed Will Have a Capacity of From 60 to 80 Tons—New Construction and Electrical Connections Allow the Furnace To Be Equipped with Eight Electrodes

BY FRANK HODSON

IN SPEAKING of large electric furnaces, the term must be understood to mean the size as compared to the average existing electric furnace. What was considered a large open-hearth furnace 10 years ago might well be classed as small today, and in the same way what now is considered a large electric furnace may be small a few years hence.

One of the reasons hitherto against the development of large electric furnaces has been that the older system of three-top electrodes does not, for good electrical and metallurgical reasons, lend itself to multiples of three electrodes. Thus the size of such a furnace is limited by the current-carrying capacity of the three largest commercial sized electrodes that can be bought and used in steel furnaces. This limit has just about been reached at 40 tons of hot metal in a furnace equipped with only three 24-ton electrodes.

Mechanically, there is no reason for electric furnaces not being built just as large as open-hearth furnaces, and if we remove this three-electrode limitation in size, we open up a new field of design and utility for the large electric furnace.

The size of a finishing electric furnace for tool steels is restricted somewhat by the necessity of casting small ingots, as compared to gun or armor ingots, and by the need for accurate control of pouring temperatures. This condition, however, does not apply to furnaces for cheaper grades of steel or for furnaces used as an intermediate process, say between the blast furnace and the finishing furnaces. Provided power can be obtained at a reasonable rate, electric furnaces of large capacity can be employed usefully and economically as a feeder to smaller finishing furnaces.

The modern metallurgical tendency is toward increased size of melting furnace. This is noticeable, particularly in recent open-hearth plants and it is recognized generally that handling large quantities of metal is much more economical than small since refining is quicker, the metal is more homogeneous and heat losses are less.

The furnace as finally developed may be described as an arc-resistance furnace which on normal operation introduces two phases of the 3-phase power supply line through two or more top electrodes and the third phase through the whole of the furnace hearth. On all recently installed Greaves-Etchells type furnaces with four or more electrodes, the system and design permit of the whole of the power being put through top electrodes or by change of position of an oil switch through top electrodes and the furnace hearth, a balanced load being obtained with either method. This arrangement gives the furnace considerable flexibility of operation, as top electrodes and high voltage can be used when melting down or when starting up a cold furnace, and the top and bottom contacts when molten bath is obtained or for refining and

From a paper presented at the Pittsburgh convention of the American Institute of Electrical Engineers, April 24-26. The author is president, Electric Furnace Construction Co., Philadelphia.

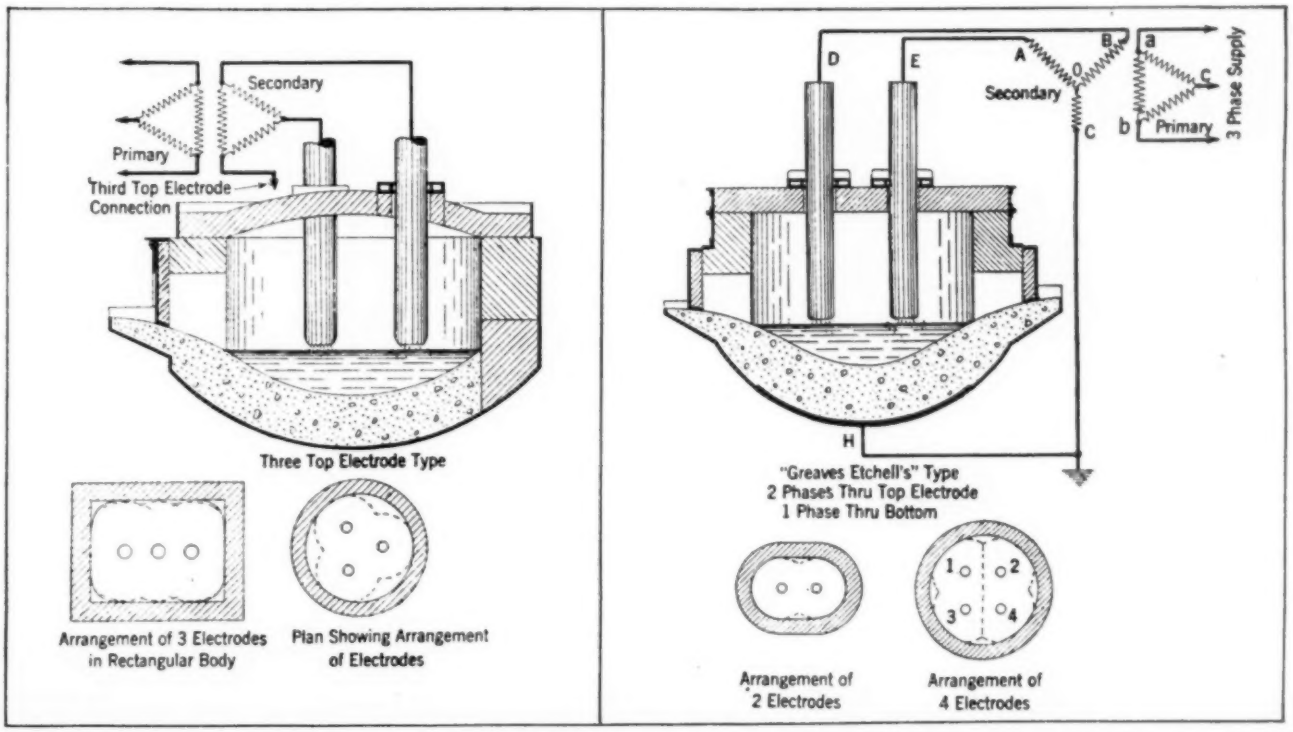


FIG. 1—(LEFT) DIAGRAM SHOWING ARRANGEMENT OF ELECTRODES AND TRANSFORMER CONNECTIONS IN THE THREE TOP ELECTRODE TYPE OF FURNACE—(RIGHT) ELECTRODES AND TRANSFORMER CONNECTIONS IN GREAVES-ETCHELLS TYPE FURNACE

superheating after melting the metal.

The general arrangement of this furnace is shown in Fig. 1, right, in which *D* and *E* are the electrodes and *H* is a sheet of copper beneath the lining of the hearth. The three terminals, *D*, *E* and *H* are connected to the legs, *A*, *B* and *C* of a star-connected transformer system, the primary windings being in delta. If the electrical resistance of the hearth were equal to the resistance of each of the electric arcs, the terminals *D*, *E* and *H* could be supplied from an ordinary 3-phase source of supply, the voltages between *D* and *E*, *E* and *H*, *H* and *D*, would all be equal and the molten metal *F* would be the neutral point of this system. However, as the hearth resistance in practice is decidedly less than the resistance of an arc, an ordinary 3-phase supply cannot be used, and in order to obtain a balanced load on the supply lines the secondary winding, *OC*, must have a smaller voltage than *A O* or *O B*.

It will be seen from diagrams that the Greaves-Etchells type furnace is not limited in size or in number of electrodes, as each group of two or four, with or without hearth connection, constitute electrically a separate furnace unit, and any multiples of two or four electrodes are quite feasible. The 60 to 80-ton furnace under construction for the Ford Motor Co. River Rouge plant, Detroit, has four banks of transformers each of 3000 kilovolt-amperes. These are just as satisfactory and safe as four separate furnaces would be, and the power input will be introduced so that a stoppage of one, two, three or even four electrodes will not necessarily mean a furnace shut down. Each electrode will operate independently, so the stoppage of the arc on one electrode will not break the other arcs.

The advent of the Soderberg continuous electrode, now operating on a number of electric steel furnaces, also may have considerable bearing on future design of large electric furnaces. For the benefit of readers not acquainted with this device, it may be desirable to say that it consists of a thin metallic casing the size of the electrode to be used, into which the electrode paste or mix is dropped. This can be made up either over the furnace, or as is done now on most steel melting furnaces fitted with the Soderberg, by jointing up outside the furnace from 12 to 18 feet of casing, filling with the mix and putting into existing electrode holders, the actual baking of the electrode being done in the furnace. The cost is the mix, plus the thin metallic casing, against finished extruded baked electrodes. Actual electrode consumption is considerably less, as the electrodes are protected by the metallic casing and there are no broken electrodes, butt ends, etc. The significant point, however, is that the size of this electrode is not limited by the size of the largest extruding press and electrodes either solid or hollow can be built far larger than called for in any existing furnace. By use of such an electrode, the design of holding capacity of the large three-top-electrode furnace can be more than doubled, although it still would have some of the inherent electrical and metallurgical defects of such furnaces.

Fig 3 shows a diagrammatic plan and elevation of the 60 to 80-ton furnace designed for the Ford Motor Co., River Rouge plant, Detroit, and now under construction. It will be equipped with eight electrodes and transformers of 12,000 kilovolt-ampere capacity. The electrodes are arranged in two rows of four, and each pair and contact plate under the hearth of the furnace, which is common to all, forms an electrical unit and is supplied by a 3000 kilovolt-ampere 3-phase transformer with the connections shown in Fig. 1, left. By means of a switch, power can be put entirely through the top electrodes. When this is done the bottom connections are thrown in series and consequently no current can flow through the hearth. As the additional current which would ordinarily flow through the hearth is distributed over the transformers and thence to the electrodes, the efficiency of the furnace is not altered and a balanced load still is maintained. The two diagrams illustrate the relations obtained in the primaries of the transformers when operating with top electrodes only, or with the top and bottom connected.

The furnace has inside dimensions of 20 feet 6 inches by 16 feet, built up of 1-inch plate. Two rockers of heavy cast iron section form the main supports and these are assisted by 12-inch I-beams placed on 27-inch centers. The rockers are so placed that the two upright channel columns in the rear rest directly on the rocker bearings. The furnace has a double lining with air space between. Fig. 2 illustrates the general design and lining. The furnace is designed on open-hearth lines, has five doors, giving access to all parts of the furnace, and tilts endwise. All doors are operated by air cylinders, having a definite stroke to prevent overtravel. The side walls of the furnace are 18 inches thick and the rear wall is given a slight arch. Roof bricks are 12 inches thick, but are thickened somewhat around the ports.

The special electrode economizers developed by the Electric Furnace Construction Co., Philadelphia, and fitted on the existing Greaves-Etchells type furnaces at the Ford Motor Co. plant will again be used on the large furnace and on the two 10-ton furnaces.

For tilting the furnace a 65-horsepower motor is used. A double spur

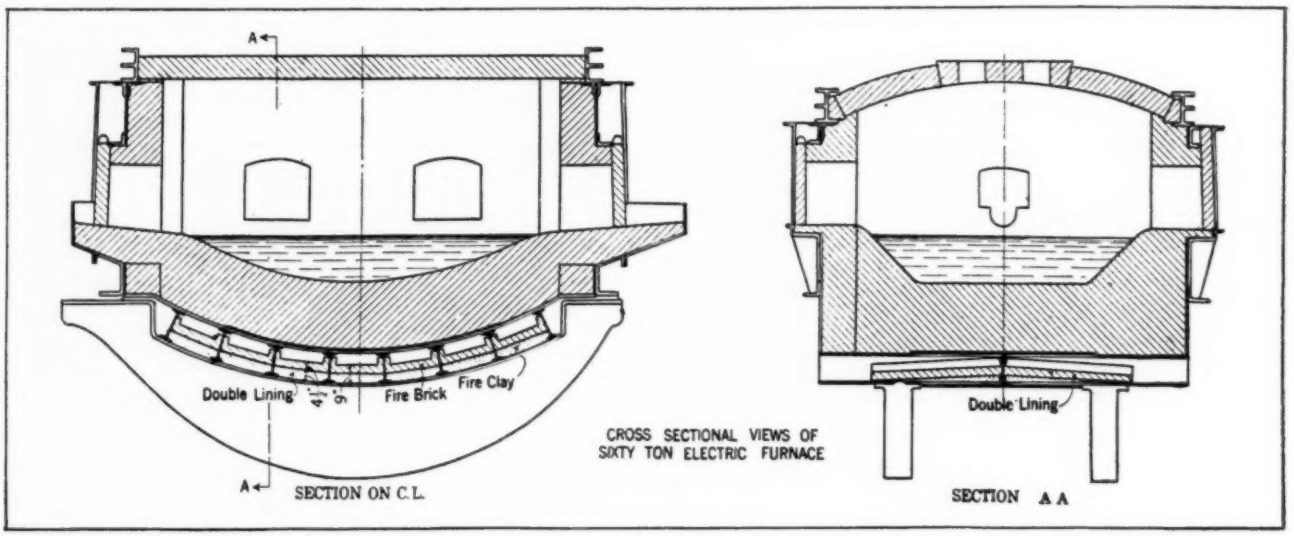


FIG. 2—SKETCH SHOWING GENERAL DESIGN AND LINING OF THE GREAVES-ETCHELLS TYPE OF FURNACE

gear reduction operates a horizontal screw, which is placed under the center of the furnace. The screw moves a nut to which are fastened two connecting rods, in turn fastened to a heavy casting bolted to beams under furnace. The screw and nut are enclosed in an oil tight housing and operate in an oil bath. Limit switches are provided to prevent overtravel.

The whole of the tilting mechanism and under part of the furnace is protected in case of a run out by a double lining consisting of plate work covered with firebrick, lying under the proper furnace shell. This lining slopes from the center outwards.

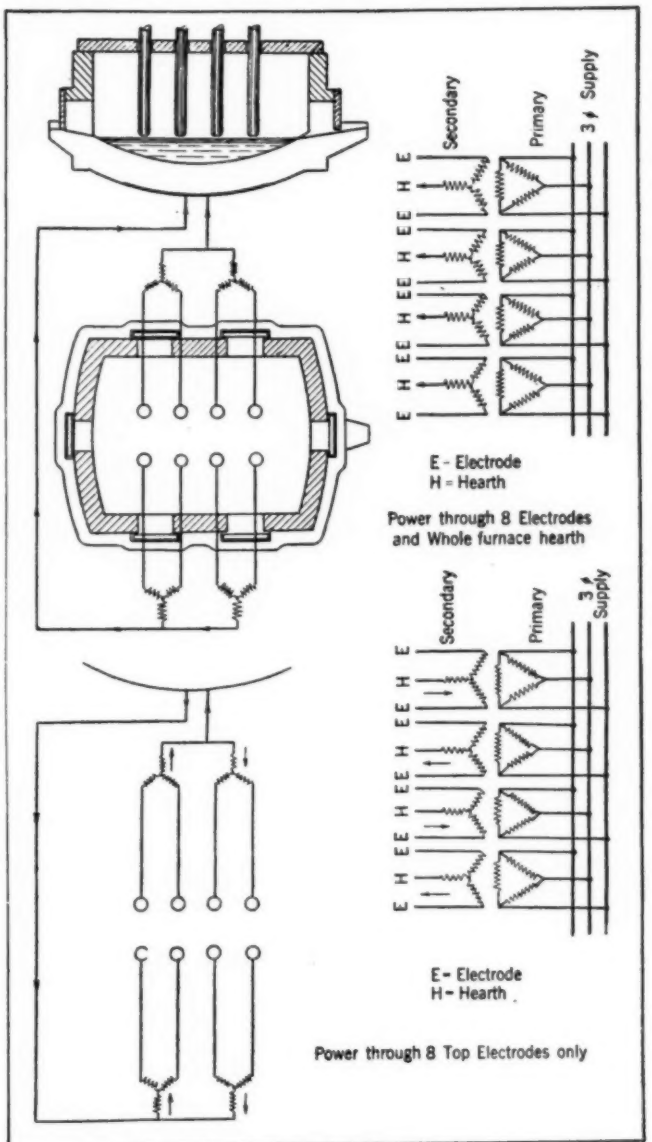


FIG. 3—DIAGRAMMATIC PLAN AND ELEVATION OF 60 TO 80-TON FURNACE DESIGNED FOR THE FORD MOTOR CO., DETROIT

Supporting the Electrodes

The electrodes and motors are carried on a top platform above the furnace, supported by six vertical channel columns with horizontal supporting beams. These main supports are suitably tied together, braced by structural members, and covered with steel plate, on which electrode motors and gearing are placed. The electrode holders are hung by two steel chains passing over sheaves to a winding drum and have insulated guide rods. This top arrangement of gearing, motors, etc., leaves the furnace body clear for metallurgical operations and enables the actual furnace shell to be designed solely for holding metal. The furnace is designed to operate on a variety of voltages and with such heavy currents that it has been necessary to pay special attention to interlacing the copper bus bars from transformers. Flexible copper strips carry current from the interlaced terminals to electrodes. The whole of the switchboard, control equipment automatic regulators, oil switches, transformers, etc., are located under the furnace stage level and the only electrical equipment showing above furnace stage will be two control pillars fitted with varicolored lights. The new plant at the Ford Motor Co. also includes two 10-ton Greaves-Etchells type furnaces, each with four electrodes and 3000 kilovolt-ampere transformers, but no description of these will be attempted in this article beyond saying that these, like the 60-ton furnace, are so designed that they can operate either as acid or basic, with power either entirely through top electrodes or merely by change of position of oil switch with power through top electrodes and the whole of the furnace hearth.

The furnace hearths are quite solid, with no studs, water cooling or embedded electrodes. The whole of the hearth acts as a huge electrode if power is put through it by the switch arrangement previously mentioned. The operation of the Ford furnaces will, in the writer's opinion, mark a new advance in the science of steelmaking and prove that the scope of the electric furnace is not confined to small melting furnaces for high grade steels but can economically be an essential part of the process of making all steel.

Match Plates of Litharge

Question: I have tried several formulas in an attempt to make a hard sand match but the material will not harden. Any information you can give me on this subject will be appreciated.

Answer: This question has been asked and answered through the columns of THE FOUNDRY several times during the past year. Briefly it may be stated that a hard sand match is made from a mixture of fine sand, boiled linseed oil and litharge. The quantity will vary with the size of the matchboard, but the proportion will remain in the approximate ratio of one quart of oil and one handful of litharge to each shovelful of sand. Fine molding sand thoroughly dried may be employed, but usually it is more convenient to gather a sufficient supply from the vicinity of the tumbling barrels or the sandblast room. The sand is spread on a board or on the bench, the oil and litharge added and then the whole is thoroughly mixed preferably by the hands of the man who is going to use it. After it has assumed the consistency of ordinary molding sand it is rammed in the match frame and a parting made as required. The finished matchboard is set away in a warm, dry place where the temperature is not over 75 degrees, Fahr., for about 24 hours. It then is given a coat or two of shellac varnish and placed in production.

Like every other job a certain degree of familiarity with the process is required before a man can turn out a creditable job in the shape of a hard sand matchboard. Preparing the material entails the loss of a considerable amount of time and progressive foundrymen are abandoning the material in favor of a special compound which may be procured from the foundry equipment and supply houses advertising in the columns of THE FOUNDRY.

The Gibb Instrument Co., Bay City, Mich., maker of electric welding equipment has increased its authorized capital stock from $75,000 to $175,000. Of the increase $40,000 will be used to provide increased manufacturing facilities.

How and Why in Brass Founding

By Charles Vickers

Formula for Duralumin

We have an inquiry for duralumin metal, used in automobile work, and as we have never made the alloy we would like to know the formula.

Duralumin is of the following composition:

	Per Cent
Aluminum	95.00
Copper	3.75
Magnesium	0.75
Maganese	0.50

As a rule this alloy is only used in the forged or rolled state. However, there is no particular reason why it cannot be cast in sand, but its properties in that condition cannot be expected to more than approximate those of its worked condition.

Encounters Porosity in Bronze Grills

We have had considerable trouble of late in obtaining castings of large flat sections which develop porosity when finished. The castings are known as ventilator grills, and in size range from 36 to 48 inches upwards. We use a guaranteed ingot, also metal newly mixed, and melt in coke-fired furnaces. The molds are prepared carefully and dried and the source of the porousness does not appear to be either steam or dirt.

As careful molding is necessary for architectural bronze castings, and the sand and methods used are to a certain extent standardized, it would appear as though the source of the difficulty could not be in the molds. It is not always easy to tell what is the cause of porosity in brass castings, especially from a distance. If the porosity is caused by something wrong with the mold, compare such molds with others made in a different kind of sand from a different pattern. If the latter do not exhibit the difficulty met in the case of the first mold, then we know the molding is at fault. However, if all castings poured from the same metal, no matter what their shape, or in what sand molded come porous, then it is obvious the metal is at fault. It is no use treating the metal for faults of the molds, or changing the molds for faults of the metal.

Using ordinary and rather coarse sand, make up one or more molds of some simple shape such as a couple of bars 1 x 2 x 10 inches, or a round object such as a stick, 1½ inches diameter and 10 inches long. In fact, it would be advisable to mold both shapes in each mold. Pour these with the same metal that is coming porous in the grills. Plane the flat piece and turn the round piece in a lathe. If both are sound, the metal is blameless, also the melting part of the process, and nothing will be gained by *treating* the metal with anything. Should the castings turned and planed prove porous, evidently the source of the trouble has been uncovered. Therefore, see the melting is so conducted there is no need to make cold additions to already melted metal to get the pots filled. This means to use a *deepener* on the crucible—which may be simply the bilge of an old crucible—to get in at one charge all the metal the crucible is going to hold. Bring it to a liquid state, cover with charcoal and heat to casting temperature. Add to every hundred pounds, 2 ounces of phosphor copper, as a maximum. Castings of metal so treated will not be porous, if the mold receives the metal quietly.

If the mold is at fault, as shown by the test castings being free of porosity, scrutinize every operation to get at the source of the trouble. Thus, is the backing sand too fine and *close?* Is the backing sand used hot?

Metal Used to Rebabbit Connecting Rods

We would like your opinion in regard to the following formula for babbitt, for rebabbitting connecting rods in automobile engines. The formula follows; lead, 46 per cent; tin, 42 per cent; antimony, 12 per cent. The metal is to be made and sold in ingot form, and must be as cheap as consistent with giving good service.

As a result of investigations regarding babbitt metals made during the war; the belief has grown that the intermediate babbitts, those containing relatively large amounts of both tin and lead, are not as good as those that have a base of tin, or those with a base of lead. Some believe that the tin-base babbitts should not contain more than 10 per cent lead, and the lead-base babbitts not more than 10 per cent tin. The specifications of the Society of Automotive Engineers have two babbitts; one of which, No. 10 contains tin, 90 per cent; antimony, 5 per cent; and copper, 5 per cent, and a brinell hardness of 17.2. A second babbitt, No. 24, contains tin, 84 per cent; antimony, 9 per cent; copper, 7 per cent. Of the two No. 10 is the more fluid metal, an important point in running thin bearings, but No. 24 will withstand greater pounding.

As far as the formula given in the query is concerned; an alloy of the following composition would be just as good as far as service is concerned.

	Per cent
Lead	75.00
Tin	10.00
Antimony	15.00

Holes Under the Surface Are Caused by Gas

We have a number of nickel bronze castings to make of the following composition: copper 81 per cent; nickel 10 per cent; manganese copper 3 per cent; zinc 6 per cent. The castings appear perfect on the surface but on being machined develop a number of what seem to be sand holes.

If the holes are clean it is evidence that they are due to gas held in the metal after solidification, or, in view of our present knowledge it may be more correct to say the gas has *not* been held in solution. These holes are due to some condition which we have learned frequently may be corrected by the addition of an element like phosphorus. Before changing the alloy try adding 2 ounces of phosphor copper per 100 pounds of metal. If the holes really are filled with dirt like sand, it is dross. A manganese copper content of 3 per cent is 2.5 per cent too much for any bronze cast in sand. Reduce the manganese copper accordingly and bring up the hardness of the alloy by adding approximately 2 per cent tin.

Molten Brass Blows Off Metal Inserts

We are casting an auto door handle in which there is a steel insert and experience trouble due to the latter causing blows. We have tried various coatings on the steel, including plumbago and coal oil, but they do not help us any. Any suggestions you may offer will be appreciated.

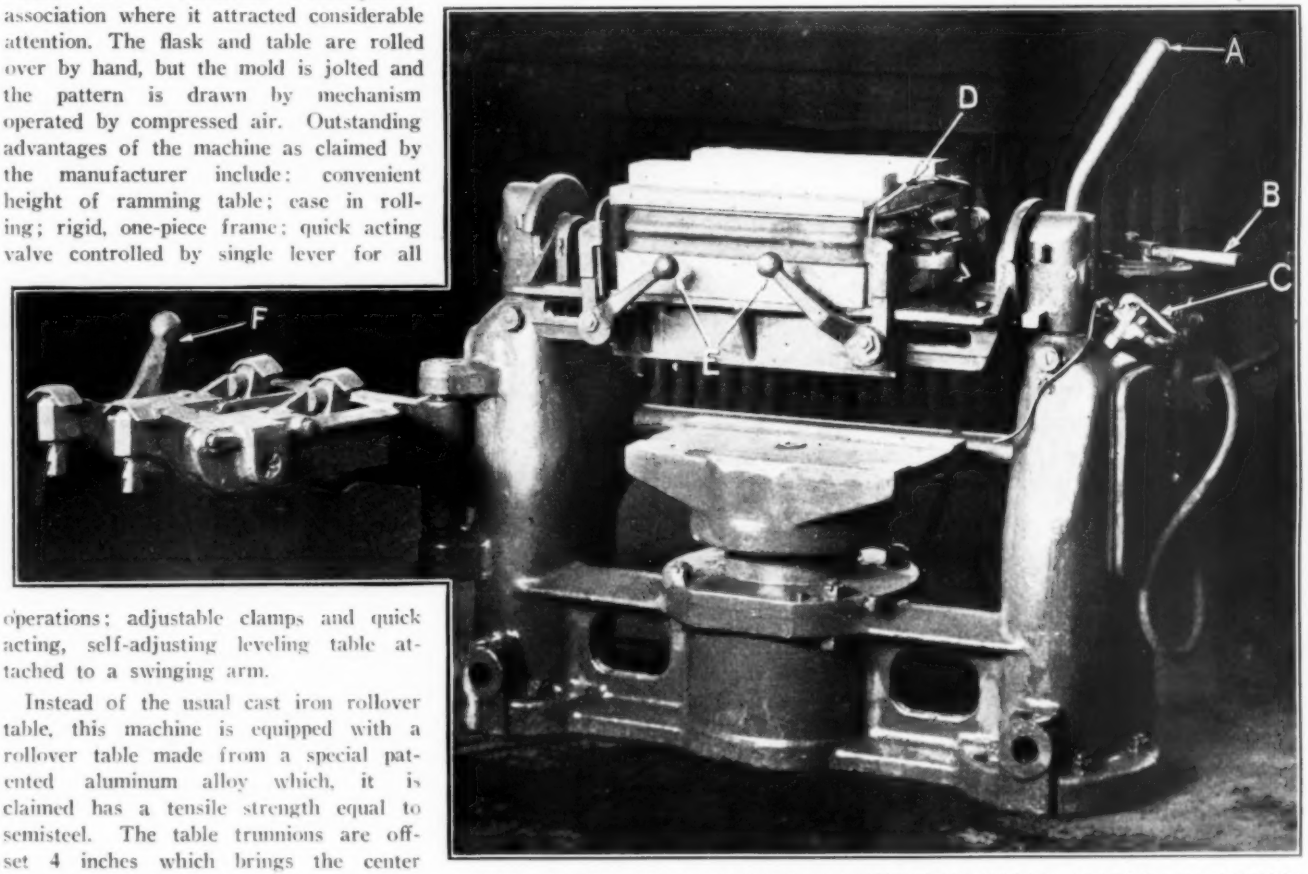
Suppose a damp skimmer or poker is

inserted into a pot of molten brass you know what would happen—sometimes a very serious explosion. If the skimmer or poker is heated there is no trouble. It is not the iron but the moisture that is responsible for the blowing. Exactly the same thing happens when molten metal surrounds a piece of cold iron inserted in a mold. The metal blows on contact because the iron is damp, and the moisture is converted suddenly into steam. Coating the iron does not help unless the coating absorbs moisture and then face the molten metal without blowing. That is the reason a steel or iron insert may be wetted with linseed oil covered with dry, sharp sand scattered thereon, afterward be dried in an oven and allow molten metal to be poured around it with impunity.

If the steel inserts are warmer than the sand of the mold, no moisture can condense on them and there will be no blowing. A sure way to overcome the trouble is to place the clean, bright steel in an oven or muffle where it is heated to around 250 degrees Fahr., and place the insert in the open mold a few minutes before it is poured. Sometimes flowing off metal heats up the insert will prevent blowing, but the safest way is to leave the molds open until ready to pour, then put in the inserts and pour.

Molding Machine Has New Features

MANY interesting features, some original and others adapted from machines already in existence have been incorporated in a molding machine recently placed on the market by the Osborn Mfg. Co., Cleveland, and shown in the accompanying illustration. The machine was shown at the recent exhibition held in connection with the convention of the American Foundrymen's association where it attracted considerable attention. The flask and table are rolled over by hand, but the mold is jolted and the pattern is drawn by mechanism operated by compressed air. Outstanding advantages of the machine as claimed by the manufacturer include: convenient height of ramming table; ease in rolling; rigid, one-piece frame; quick acting valve controlled by single lever for all operations; adjustable clamps and quick acting, self-adjusting leveling table attached to a swinging arm.



QUICK ACTING, JOLT RAMMING MACHINE ESPECIALLY ADAPTED TO MAKING A MISCELLANEOUS LINE OF CASTINGS

Instead of the usual cast iron rollover table, this machine is equipped with a rollover table made from a special patented aluminum alloy which, it is claimed has a tensile strength equal to semisteel. The table trunnions are offset 4 inches which brings the center line of the flask close to the center of gravity, this feature together with the lightness of the plate facilitate the rolling over operation. The table on the machine shown will accommodate a flask with maximum dimension 30 x 24 inches and a pattern draw of 10 inches. The center of the rollover table is open thus permitting the use of a pattern with deep pockets or a corebox requiring over 10 inches clearance in the draw. The table is rolled over by the handle *A* and is so designed that when rolled over it will hold against its stop without a locking device.

The clamping device is shown at *D* and *E*. The two levers *D* are grasped by the operator with both hands and revolved through approximately 180 degrees. A cam attachment on the lower end of each lever pulls the clamp *D* firmly down on the bottom board. Immediately after the flask is rolled over the levers are thrown in the opposite direction and the clamps are released. The rollover table is slotted at both ends on the sides to provide a ready means of adjusting the clamps for flasks of various lengths. The shafts on which the clamping handles are fitted pass through these slots and are held in position by nuts on each side of the table.

A unique jolt design is incorporated in this machine by which the jolt table, piston and cylinder are raised approximately 6 inches before the jolting operation commences. At 80 pounds pressure it is stated that a force equal to 45 tons supports the jolting anvil.

The lever shown at *C* controls a valve which discharges a jet of air through two small pipes (only one is visible in the illustration) for the purpose of blowing all loose sand off the top of the jolt table.

One valve *B* controls the entire cycle

of operation, jolt, pattern draw, and vibration. The lever moves over a dial marked in raised letters to indicate the sequence of operation. Just before the handle touches the *draw* position the vibrator automatically starts and when the handle is moved over to the *fast draw* position it stops, also automatically. The automatic control of the vibrator is accomplished through a series of ports in the valve plates.

By the use of a simple cam mechanism controlled by the lever *F* the leveling pins in the flask receiving table are depressed approximately 1 inch when the locking handle is moved in one direction. They are brought into contact with the bottom board of the flask when the handle is moved in the opposite direction. When the pins are lowered the leveling device is swung under the flask thus eliminating two movements required with former machines viz: raising the mold to swing the leveling car underneath and then lowering on the leveling pins, which have a 3-inch adjustment in 1-inch steps.

Patternmaker Must Anticipate Molder

BY M. E. DUGGAN

IN MANY pattern shops the apprentice is encouraged to spend too much time in sand papering, waxing and finishing the pattern and too little time in learning how the pattern is to be molded, or how the cores are to be made and assembled in the mold. In the foundry recently, I saw a molder making the mold for a punch press frame casting that weighed 2750 pounds. The pattern was about as disreputable a specimen as I ever have seen, but the resulting casting would have been no better or smoother if the patternmaker had spent hours in putting a perfectly smooth finish on the pattern. The pattern was designed correctly and the minor surface defects easily were smoothed over on the face of the mold.

An example of a pattern made by a man not familiar with foundry practice is shown in the accompanying illustration Fig. 1. In the illustration the cope side is shown down, but the patternmaker originally designed it to be molded in the opposite position. The ring B and the hub F were made loose on the line I. The ring C was made loose on the line J. The hub E and the six arms D were fastened securely to the center web and rim A. The patternmaker assumed that the mold would be made in a 3-part flask. The rims A and B were drafted liberally in opposite directions from the center line.

In the foundry the mold was made in a 2-part flask with a cover core over the ring C as shown in Fig. 1. The ring A with web, hub and arms attached was laid on a board, web down and surrounded by a drag that was rammed full of sand up to the top of the loose ring C. The ring was removed and after the ring cavity was covered with a number of cover cores the remainder of the drag was rammed full of sand and rolled over. The rim B and the hub F then were set in place and a cope rammed in the usual manner and lifted off. The rim B and the hub F were drawn out of the cope and the rim A with web, hub and arms were drawn out of the drag. This method of making the mold did not meet with the molder's approval and merely was adopted in the spirit of making the best of a bad job.

The altered pattern, made according to the molder's suggestion is shown in Fig. 2. The hub G was attached permanently to the arms H and arranged to drop easily inside the rim which in this instance was all in one piece and tapered on the outside from top to bottom. The lower hub and the web were attached permanently to the rim and in this manner the entire pattern was molded in the drag. The upper hub and the arms were suspended from a wood screw and helped to support the hanging body of sand while the cope was being lifted off. The altered design simplified the work of the patternmaker and resulted in a stronger pattern. It answered the requirements of the molder to an extent that enabled him to practically double his output.

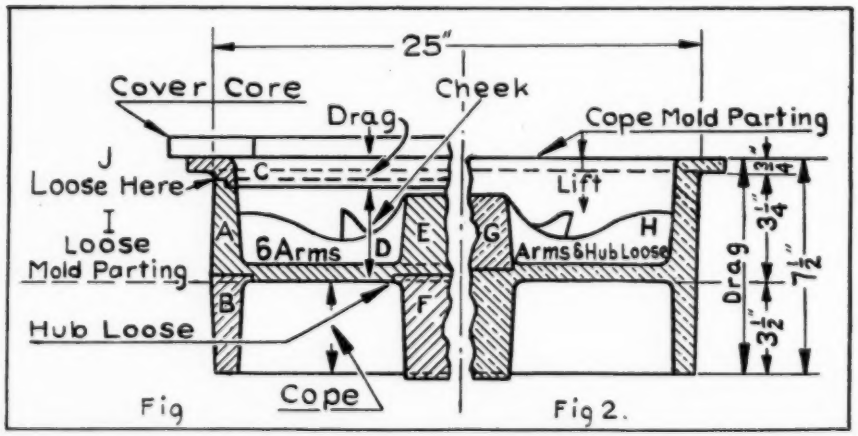


FIG. 1—THE PATTERN AS IT WAS ORIGINALLY CONSTRUCTED. FIG. 2—THE MANNER IN WHICH A NEW PATTERN WAS MADE TO CONFORM TO THE MOLDER'S REQUIREMENTS

Melts with Oil in Air Furnace

(*Continued from page* 437)

the furnaces are 11 and 12 tons. The amount of oil used varies little in proportion to the charge, but may in some instances be at the minimum figure while operating the furnace at capacity. Our best record for oil consumption was the melting of 781.6 tons of iron with 43,674 gallons of oil, an average of 55.8 gallons per ton. This was made over a three weeks' period and includes the total melt of three furnaces.

The average for four furnaces for the past 4 months is approximately 65.0 gallons per ton. This means a fuel cost of about $3.50 per ton of metal melted. A comparison with coal, for one day's operation, on this basis would be about as follows on furnaces melting two 10-ton heats:

	Oil	Coal
Fuel cost	$70.00	$77.80
*Operation	6.00	10.80
One laborer hauling coal.	....	3.50
Ash removal	....	0.50
Total	$76.00	$92.60

*One operator on oil, two firemen on coal.

A much larger saving is made on maintenance of the furnace. On 8-ton heats over a period of 203 oil heats, and 126 coal heats, maintenance cost was $3.01 per ton in the case of oil, and $6.56 per ton while firing with coal.

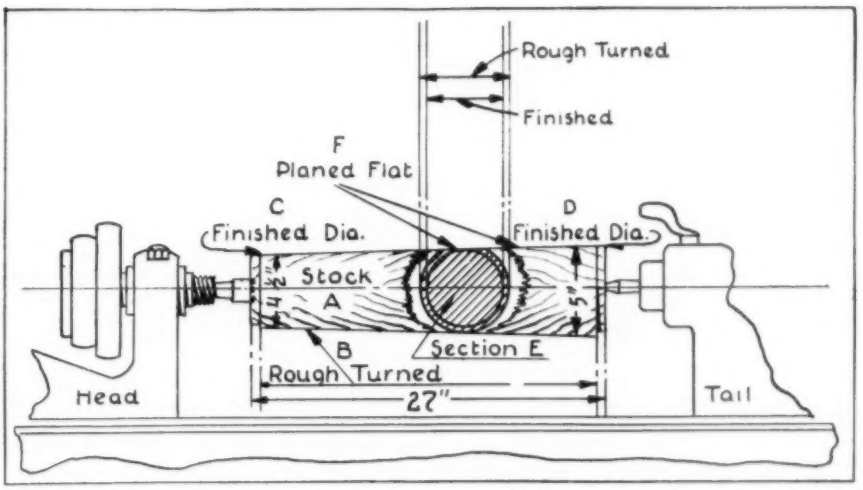
An average of 6 bungs are relined

each 11 heats. The life of side walls is about 40 per cent longer than when coal was used. Bungs over the combustion chamber last from 2 to 3 months, though the first five bungs will stand up over a year. The life of the throat and the bungs over the rear end of the furnace is slightly longer, though we possess no reliable data as to length of service. Bungs near the stack have not been relined during the time we have been operating on oil.

Specially Designed Spout Acts as Skimmer

By H. D. Davis

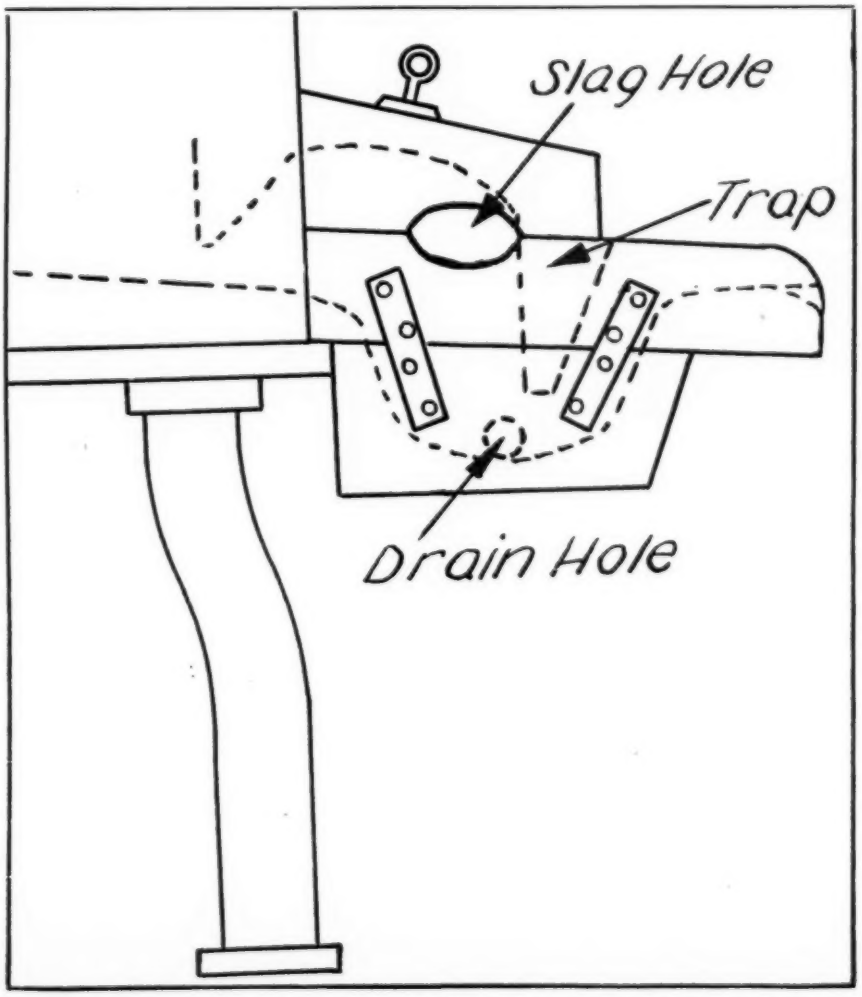
The spout shown in the accompanying illustration is used in connection with a cupola which runs a constant stream for the duration of the heat. It is claimed that it removes practically all the slag from the molten iron and delivers a perfectly clean stream to the ladles. In addition the hood covers the spout and tap hole and automatically removes the usual hazard from sparks and splashes incident to an open spout and tap hole.



A FLAT SPACE PLANED FROM END TO END SERVED AS A GUIDE IN TURNING A TAPERED HUB

An opening was made in the bottom of the regular spout and then the reservoir box was attached by means of two straps on each side. The reservoir box is provided with two holes, one on each side as shown. The lower hole is used for draining the reservoir at the end of the heat and the upper hole is to allow the slag to flow through while the stream is running. The cover box is provided on the inside with several ribs to hold the lining and on the outside with an eyebolt, cast in, for lifting it on and off. Arch brick set in the spout as shown forms the trap for the slag.

At the beginning of the heat the drain hole is left open and a small quantity of iron allowed to run through. The hole then is stopped and the stream allowed to run over the end of the spout as usual. After the heat is finished the drain hole is again opened and the iron in the well allowed to run out. The tap hole in the cupola is made larger than usual to prevent any possibility of choking and the hole in the spout through which iron comes to the ladle is made slightly smaller than the tap hole.



GENERAL ARRANGEMENT OF SKIMMER SPOUT SHOWING SLAG AND DRAIN HOLES

Kink in Pattern Turning

By M. E. Duggan

Recently I saw a patternmaker turning a long hub for a pattern. It was 27 inches long and tapered in diameter from 5 to 4½ inches and in ordinary practice would have been a *cut-and-try* job tested by a straight edge at frequent intervals. This man handled the job in another manner. He cut the stock the exact length required and rough cut the corners on the band saw. He then placed it in the lathe and rough turned it as shown at *B* in the accompanying illustration. He turned a narrow strip at each end down to the finished size *C* and *D* and then planed a flat from one end to the other as indicated at *F*. The flat surface was rubbed with blue chalk and by closely watching the chalked surface he turned the piece to a finish without either stopping the lathe or trying the surface with a straight edge. It will be noted that the smaller diameter is at the head end of the lathe and therefore planing the flat is a right hand operation.

THE FOUNDRY

Registered U. S. Patent Office

A semimonthly journal devoted to all branches of the foundry trade

Published by
THE PENTON PUBLISHING CO., CLEVELAND, O.

BRANCH OFFICES

BOSTON.....426 Old South Bldg.
CHICAGO.....1147 People's Gas Bldg.
CINCINNATI.....504 Edwards Bldg.
NEW YORK.....2203-2206 No. 220 Broadway
PITTSBURGH.....2148-49 Oliver Bldg.
SAN FRANCISCO.....675 Monadnock Bldg.
WASHINGTON, D. C.....84 Home Life Bldg.

FOREIGN OFFICES

BIRMINGHAM, ENGLAND.....Prince's Chambers
LONDON, ENGLAND.2-3 Caxton House, Westminster, S.W. 1
PARIS, FRANCE.....23 Rue de la Bienfaisance VIIIe
Cable address, IROTRAPEN, London

SUBSCRIPTION

United States and Mexico.....$3.00 a year
Canada.....$4.00 a year
Great Britain and other Foreign Countries.....£1:0:0 a year
Single Copies.....25 cents
Copies published three months or more previous to date of current issue, 50 cents each.

ADVERTISING

All communications relating to advertising copy, discontinuances, etc., must be received on the 1st and 15th of the month preceding date of publication.

Member, the Audit Bureau of Circulations, Associated Business Papers, Inc., and National Publishers Association

Entered at the Post Office at Cleveland as Second Class Matter

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Apprentice Training Live Issue

ONE of the perennial problems to engage the attention of the American Foundrymen's association ever since its organization, has to do with devising a workable system of apprentice training to provide an adequate supply of skilled molders, not only to take the place of those who drop out through natural causes, but also to keep pace with the growth and expansion of the foundry industry. This subject received a considerable measure of attention even before the foundrymen became organized in a technical association. It also furnished a theme for various correspondents in technical papers before that time. Attempts have been made at different times to establish a training station where young man could be taught the trade; but invariably the project has fallen through. Of course, proponents of the theory, are prepared to advance plausible reasons to explain why the experiment failed, but plain, practical foundrymen know that, like any other business, the only way to learn to do a thing properly is actually to do it with one's own hands. The only way to learn to make castings under commercial conditions is to work in a shop with journeymen molders who are paid a certain wage for performing a certain amount of work that has a definite cash, market value.

An apprentice working in company with other apprentices, exclusively, under the direction of an instructor never will get the same conception of the importance of his job as an apprentice working among a crowd of molders, each one of whom either has to deliver the goods or quit. It is not in the nature of the average boy to take his work seriously. Usually he is just out of school when he enters one of the apprentice classes. He still has the typical schoolboy attitude to squirm through with a minimum amount of trouble and study. He looks upon the work merely as the unpleasant part of the day's activities. A superficial knowledge of the trade may be gained in this manner, but the skill of hand and eye. the comprehensive and balanced judgment which characterize the competent molder, in fact the elements without which a molder is not a molder, cannot be acquired or developed on such a flimsy foundation.

At the recent convention of the American Foundrymen's association held in Cleveland, a symposium of half a dozen papers was presented on the subject of apprentice training and a considerable amount of discussion developed at one of the technical sessions devoted to that phase of the foundry industry. Expressed opinion decided practically unanimously that the question yearly is becoming more acute, but the various solutions proposed differed as widely as the geographical location of the authors of the various papers.

Stripped of all equivocation, ornamental verbiage and all the other usual embellishments by which people avoid laying their finger directly on the sore spot, the situation has reached a point where instead of charging a boy a premium to teach him a trade, it now is necessary to pay a boy a wage to induce him to learn a trade and the only stumbling block in the way of putting the idea in force is to convince employers to that effect.

The idea may sound radical, but many changes have come over the foundry industry since the days when a boy was paid 30 cents a day and was supposed to board himself. We must accept conditions as they are, for a new day has dawned.

Trade Outlook in the Foundry Industry

HESITANCY has marked the general trade situation the past two weeks and manufacturers are beginning to ask what it means. In determining this it must be considered that no restriction of credit exists, which was one of the main factors in causing the recent depression. Neither is there an over stocked condition in any field. On the other hand, the great expansion of industrial activity in recent months has carried the production of basic industries 69 per cent over the low point of 1921, and it now is 10 per cent higher than the peak period of 1920. Prices also have advanced considerably.

Costs Is Vital Factor

Price increase has been so marked in building materials and labor that new projects involving many millions of dollars have been held in abeyance in all sections of the country. This is welcomed by builders in general as it is felt a real slump in building operations will be brought about unless costs recede sufficiently to release the huge back log of construction now being held up. No scarcity of work in the building line is apt to develop for some time owing to the large number of projects started, and in the meantime the national construction council is endeavoring to bring building costs down. How the question of costs may effect other lines of production is shown by the fact that March imports exceed exports for the first time since 1914. In this month imports amounted to $402,000,000 against exports of $341,162,000, showing that costs abroad are low enough to overcome the barrier of a high tariff and that foreign countries are producing enough surplus to make a marked impression on the trade of this country.

Prices of Raw Material for Foundry Use

CORRECTED TO MAY 25

Iron		Scrap	
No. 2 Foundry, Valley	$30.00	Heavy melting steel, valley	$22.50 to 23.00
No. 2 Southern, Birmingham	27.00 to 28.00	Heavy melting steel, Pitts.	21.50 to 22.00
No. 2 Foundry, Chicago	32.00 to 33.00	Heavy melting steel, Chicago	19.00 to 19.50
No. 2 Foundry, Philadelphia	31.76 to 33.13	Stove plate, Chicago	18.50 to 19.00
No. 2 Foundry, Buffalo	29.00 to 30.00	No. 1 cast, Chicago	25.25 to 25.75
Basic, Valley	29.00	No. 1 cast, Philadelphia	23.00 to 25.00
Basic, Buffalo	29.50	No. 1 cast, Birmingham	23.00 to 24.00
Malleable, Chicago	32.00 to 33.00	No. 1 cast, Buffalo	22.00 to 23.00
Malleable, Buffalo	30.00	Car wheels, iron, Chicago	23.50 to 24.00
Coke		Railroad malleable, Chicago	25.50 to 26.00
Connellsville foundry, coke	$6.50	Agricultural mal., Chicago	23.50 to 24.00
Wise county foundry, coke	8.00 to 8.50	Malleable, Buffalo	24.00 to 25.00

Prosperity on All Sides

At present all lines of manufacture are stressed to the utmost and slackness is seen only in new business coming forward. Users of pig iron are holding off purchases as long as possible in hope of lower prices which have not yet materialized, although a softening in the price of pig iron is noted in the Buffalo and Valley markets. Surveys of the situation indicate that little stock is held by foundries, and if castings production is maintained at its present high rate the foundries will soon have to come into the market for iron. Coke prices have dropped somewhat and it is easier to secure prompt delivery of this fuel. That steel mills and foundries were more heavily stocked with refractories than with pig iron and coke is indicated by the falling off in sales of fireclay and silica refractories in April, when new orders of fireclay brick fell off 40 per cent as compared with March. The usual seasonal slack in automobile production shows no signs of developing except in the case of a few of the smaller producers who are beginning to curtail production. However, the larger producers are taking castings at the same rate as they have been for the past few months. The revised figures for April production show a new monthly record of 381,745 cars and trucks, or at the annual rate of 4,580,940 cars and trucks. Little let up is noted by manufacturers of accessories who usually feel the slack before the automobile plants do.

Heavy Back Log

The potential strength of the situation is indicated by the huge unfilled orders for railroad cars and locomotives in the hands of manufacturers. An indication of this is shown in a report of the department of commerce which shows that there were on the books of the principal manufacturers at the end of April, orders for 2204 locomotives, compared with 617 at the same time last year. Car manufacturers are equally well situated and cannot fill new orders for a number of months. This together with the activity in the automotive field helps to sustain the malleable iron industry which is working at about 70 per cent of capacity. At this rate orders about equal output. The cast-iron pipe foundries also have large orders on their books and are not affected by the lull in orders. General jobbing gray iron foundries are not as busy as they were last month, but the falling off is only slight. In some specialties the gray-iron foundries are rushed to capacity, notably those making tire molds to supply the rubber industry which is exceptionally busy. An average of the gray-iron foundry activity in Ohio is indicated by the report of the Ohio State Foundrymen's association which shows a slight tapering off compared with March. During April operations were 79.9 per cent of normal compared to 83.2 per cent in March. Manufacturers of textile machinery and builders hardware in New England are operating full. Brass shops supplying the building trade note a decrease in production, but other brass and aluminum foundries are operating almost as full as in April. Aluminum producers estimate that the present year's consumption of that metal will be 30 per cent in advance of the highest total ever used in a 12-month period. Users are being multiplied and automobile lines are employing more aluminum.

Nonferrous Prices

Prices for nonferrous metals, based on New York quotations in *The Daily Metal Trade* of May 25 follow: Casting copper, 15.00c; electrolytic copper, 15.25c to 15.37½c; Straits tin, 42.37½c to 42.50c; lead, 7.25c to 7.37½c; antimony, 7.25c; aluminum, No. 12 alloy, open market, 23.00c to 25.00c. Zinc is 6.50c to 6.55c, E St. Louis, Ill

Personal

Howard B. Jacobs has been promoted to be general foreman of the Egyptian Iron Works, Murphysboro, Ill.

A. T. Hinckley, of the National Carbon Co., Niagara Falls, N. Y., recently was elected president of the American Electrochemical society.

William L. Newlands has accepted the position of foundry superintendent of the American Engineering Co., Plant No. 2, Philadelphia.

Nils Anderson, president of Debevoise-Anderson Co., New York, has been elected a director of the West Bergen Trust Co., Jersey City, N. J.

Frank H. Mahler has resigned his position as superintendent of the Peoria Malleable Castings Co., Peoria Ill., and is now located in Benton Harbor, Mich.

Howard Coonley, head of the Walworth Manufacturing Co., South Boston, has recently been elected president of the Boston chamber of commerce for the coming year.

E. J. Forsythe is now foreman of the Cream City Foundry Co., Milwaukee. Mr. Forsythe was at one time connected with the Denver Iron Works & Foundry Co., Denver.

Thomas C. Brobst, formerly assistant foreman of the Olney Foundry Co., Philadelphia, has accepted the position of assistant superintendent of the Russell Wheel & Foundry Co., Detroit.

Frank E. Fitts has been appointed manager of the Boston office of Rogers' Brown & Co. jointly with H. W. Fernald. For many years he was in the company's office at Pittsburgh but recently in New York although formerly associated in the Boston office.

Percy D. Schenk, Duriron Co., Dayton, O., has been appointed to on the advisory committee of the National Exposition of Chemical Industries. This committee will conduct the exposition to be held in the Grand Central Palace, New York, during the week of Sept. 17.

F. J. Miller has become connected with the National Grinding Wheel Co., Inc., Buffalo, in the capacity of sales engineer. He will represent the National company in Ohio. Formerly he was connected with the Niagara Falls, N. Y., plant of the Norton Co., Worcester, Mass.

Cupola to Melt Iron for Radiator Castings

Question: We are going to install a new cupola 45-inch inside diameter for melting the iron for our radiator castings. We require exceedingly fluid iron for this purpose and therefore would appreciate an expression of your opinion on the following points: 1. Dimension and number of tuyeres required. 2. Volume and pressure of air. 3. Height of charging door above bed. 4. Ratio of coke or other fuel to iron. 5. Is coal preferable to coke? 6. Will the iron be hot enough to pour the castings if we first catch it in a reservoir ladle in front of the spout and then transfer it to the pouring ladles? 7. What composition is most suitable for radiator castings?

Answer: If you have back copies of THE FOUNDRY we would suggest first that you consult the Jan. 1, 1923, issue. On Page 1 and several succeeding pages you will find an illustrated description of one of the most prominent foundries in the country devoted to the manufacture of heaters and radiators. We cannot do better than recommend you to adopt many points in the practice outlined, with the necessary modifications occasioned by the relative capacity of the two plants.

Your questions taken in the order presented may be answered specifically as follows:

1. A practically continuous tuyere 6 inches high will prove satisfactory.

2. 4000 cubic feet per minute at about 12 ounce pressure.

3. The height is optional and is governed to a considerable extent by local conditions. The minimum height may be set down as one that will contain three complete charges before the wind is put on. From 10 to 12 feet usually is considered a convenient height. 4. The ratio of coke to iron is based on the amount of coke required to form a layer approximately 4 inches thick. Coke varies in weight in different parts of the country and therefore it is impossible to lay down an arbitrary amount in pounds. You can determine the amount for yourself by placing a number of fire brick on edge around a 45-inch ring chalked on the charging floor. Fill this enclosure level with coke and then weigh the coke. The amount then can be used as a standard either by weight or measure. For light, thin castings iron may be charged in the proportion of 7 or 8 pounds of iron to one pound of coke. Under ideal conditions, high grade foundry coke, clean iron, skilled cupola help and adequate air supply the proportion may be raised to 9 or 10, but this is exceptional.

5. No. Anthracite coal will melt iron satisfactorily and at one time was used quite extensively for the purpose. However, in recent years it has been found that coke is just as satisfactory and since it is less expensive it has been adopted practically universally.

6. Yes.

7. Analysis of iron suitable for radiator castings follows: Silicon, 2.00 to 2.25 per cent; sulphur, under 0.08 per cent; phosphorus, 0.40 to 0.60 per cent; manganese, 0.50 to 0.70 per cent. The charge is made up in varying proportions of pig and scrap, depending on market conditions, but usually will approximate 50 per cent scrap and 50 per cent pig iron.

Postpone Standardization of Refractories

Because of the small attendance at the preliminary conference on standardization and simplification of sleeves, nozzles, stoppers, and runner brick, held May 21, in Washington, no action was taken, and those attending adopted resolutions asking the department of commerce to call a general conference of manufacturers and consumers of these refractories. This general conference probably will be called about June 18. Although over a score of invitations were issued for the conference of May 21 it was attended only by representatives of the Bethlehem Steel Co., the American Foundrymen's association, the A. J. Haws & Sons, Ltd., Johnstown, Pa.; the Vesuvius Crucible Co., Swissvale, Pa.; the Ross-Tacony Crucible Co., Philadelphia; and the United States bureau of standards.

THOMAS ASPINWALL

Veteran Founder Retires

Thomas Aspinwall for over 30 years superintendent for E. A. Williams & Son, brass founders, Jersey City, and Elizabeth, N. J., and for 63 years in the service of the company, was pensioned and retired on May 1, 1923. He began work for William Williams, the founder of the company, in 1860, and under him learned the molder's trade. Eventually he became one of the most expert and skilled men in the brass foundry line in the country. During his early connection with this company, he either himself made or supervised the making of many castings that now are regarded as of exceptional historical interest. For example, bronze gun parts for the earlier type breech loading field pieces and many other ordnance castings; bronze parts for the MONITOR and the STEVENS FLOATING BATTERY were made by Mr. Aspinwall for these vessels which were built in yards near the foundry.

He personally supervised the making of some of the first aluminum castings in this country. Later he made aluminum castings for several cup defenders in the international yacht races, and also for the HOLLAND the forerunner of the modern submarine. In 1872 he was appointed foundry superintendent and served in that capacity until 1906 when he was relieved of duty and placed in charge of the pattern department where the work was less exacting and consequently more in keeping with his advancing years. He remained in this position until May 1, 1923 when he retired on a pension to his farm in northern New Jersey.

Entertains Foundrymen

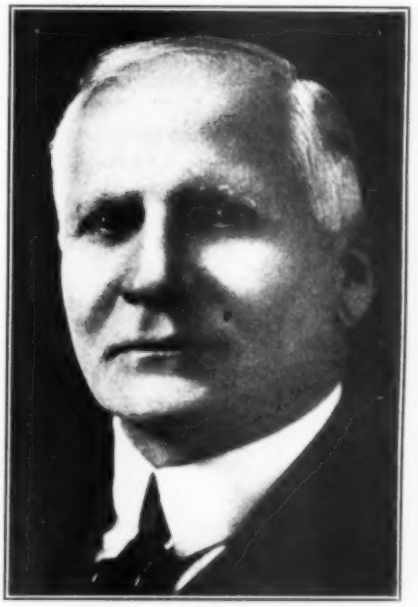
At the invitation of the General Electric Co., the May meeting of the New England Foundrymen's association was held May 9 at the River Works plant of the company, West Lynn, Mass., instead of at the Exchange club, Boston, as is customary. The meeting started at two o'clock in the afternoon and included an inspection of the various foundries and other departments of the large plant. A complimentary dinner served from the company kitchen was followed by a talk by Nelson G. Darling, manager of the River works. Later H. M. Lane, industrial engineer, Detroit, spoke on "Foundry Riggings Speed Up Output."

To Hold Post Convention Tour to Creusot

Arrangements have been made for a limited number of members who may be taking the trip to Eastern France and Belgium to visit the Le Creusot plant of Schneider & Cie., the largest steel work in France, builders of the famous 75-millimeter gun. This party will be limited to twelve and therefore the first twelve applications will complete the group. Details of the trip will be arranged after arrival in Paris. The party will leave Paris, Monday Sept. 17, from the Gare de Lyons, at 3:15 p. m., and returning will leave Creusot, Tuesday evening, Sept. 18 at 8:28 p. m., arriving in Paris, Wednesday morning. The party will be conducted by V. C. Faulkner, member of the council of the Institution of British Foundrymen, whose headquarters in Paris will be at the Hotel Roblin. The party will be the guests of Messrs. Schneider & Cie. during their stay at the works. The arrangements for this trip will be in Paris. The cost will be about $15.00 from Paris to Creusot and back.

Thomas H. Simpson Dies

Thomas H. Simpson, founder and president of the Michigan Malleable Iron Co. and the Michigan Sprocket Chain Co., died at his home in Detroit, May 9. Mr. Simpson was born at McConnellsville, O., in 1859. After leaving the public school he became interested in the iron and steel business, and about 40 years ago moved to Detroit where he became associated with Theodore Buhl. Wells W. Leggett, and others who were officers of the old Michigan Malleable Iron Co. He was instrumental in reorganizing the company and supervised the building of the Delray plant. Recognizing the value of seamless steel tubing he organized the Detroit Seamless Steel Tubes Co. Mr. Simpson also was interested in a number of other manufacturing companies, including the Monarch Steel Castings Co., the American Chain & Foundry Co., the Monarch Brake Beam Co., and the Detroit Valve Fitting Co.



THOMAS H. SIMPSON

Mr. Simpson was a member of the Detroit club, the Detroit Athletic club, the Country Club of Detroit, the Old club, the Sons of the American Revolution, and of the Masonic order. He took a great interest in the welfare of his employes and in his will he bequeathed $175,000 in gifts to 83 em

ployes who had worked with him for many years. He also willed the family homestead at McConnellsville, O., to that city for a public library. The remainder of the estate was left to his widow.

Obituary

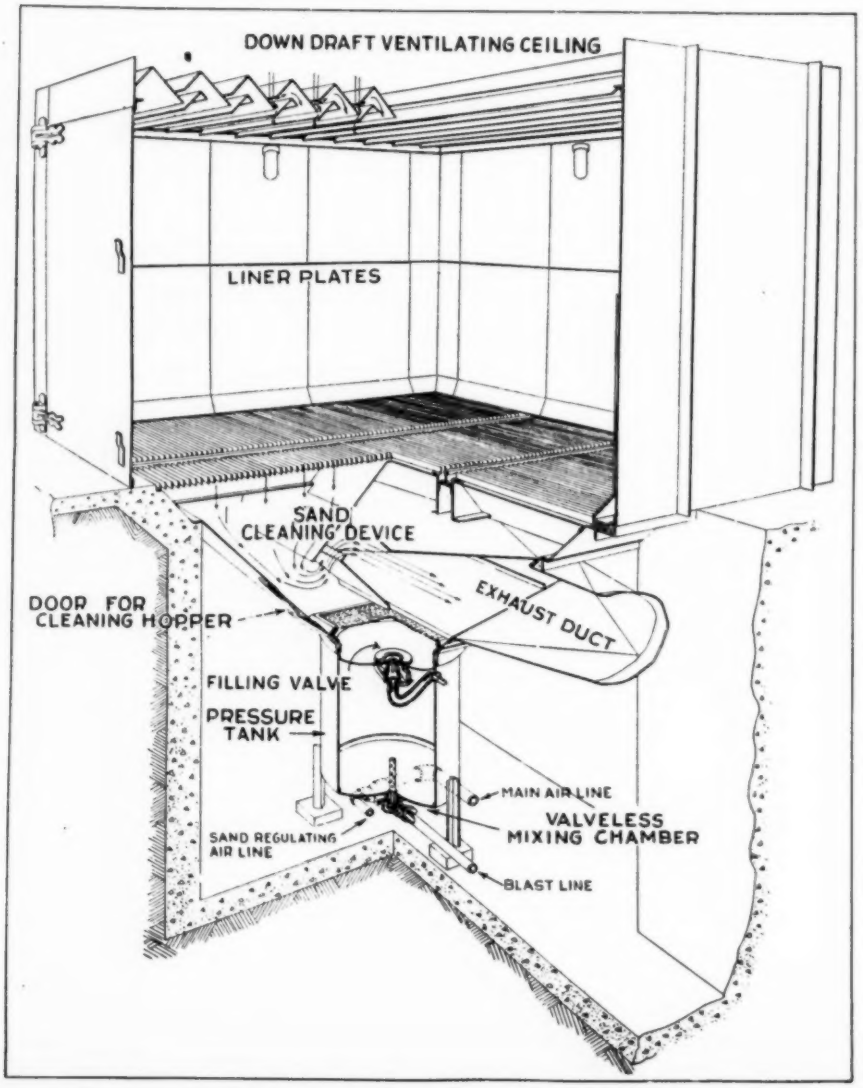
Thomas P. Greenhow, prominent metallurgist and foundryman, died at his home in Detroit, March 31. Mr. Greenhow was born in Petersburg, Va., Nov. 20, 1865, graduating from the Michigan Military institute as metallurgist and chemist. He received his early experience in the foundry and metal industry in eastern plants. He was employed by J. K. Dimick, Pipe & Foundry Co., Birmingham, Ala., as metallurgist, and in 1904 entered the employ of the United States Cast Iron Pipe & Foundry Co., Addystone, O., in the same capacity. In 1914 he organized the Mal-Gra-Castings Co., Cambridge City, Ind., of which he was president and general manager. On account of illness he disposed of his interest in this company and in 1917 entered the employ of the Buick Motor Co. at Flint, Mich., as metallurgist of their foundry. In 1920 he was made general superintendent of the Buick factory No. 20. He opened an engineering office in Flint, in July, 1922, to promote a patented method for casting soft iron cylinder blocks on a metal faced core, and to do consulting work among the foundry trade. At the time of his death he was managing and operating the foundry of the Stearns Motor & Mfg. Co. He also was owner and president of the Chi Kote Mfg. Co., Detroit.

Lewis Haldeman, a well known Chicago foundryman, a foreman in the Sheffield Foundry, 2021 Herndon avenue, was killed May 14 when a casting weighing several tons was dropped from a crane, crushing him.

Henry Woodland, secretary and treasurer of the Allis-Chalmers Co. died May 14 at his home in Milwaukee from apoplexy. Previous to 1901 when he went to Milwaukee he was treasurer of the Gates Iron Works, Chicago.

Daniel W. Voorhees, president and general manager of the Peru Plow & Wheel Co., Peoria, Ill. died in that city May 7, as a result of an attack of influenza. He was unusually well known in the agricultural implement industry and the iron and steel trade.

Frederick K. Snyder, for 25 years superintendent for J. B. Prescott & Son, Webster, Mass., iron founder, died at his home in that town, May 4, aged 56 years. He was born in Germany and had lived in Webster 50 years.



THE VENTILATING CEILING IS A SYSTEM OF ANGLES AND BAFFLES RIGIDLY TIED TOGETHER

Ventilating Ceiling on Sand Blast Room

The American Foundry Equipment Co., New York, is installing on its down draft sand-blast rooms a ventilating ceiling for which patents have been applied. The roof of the room is a system of angles and baffles rigidly tied together and so arranged that the fresh air can enter freely but no abrasives can shoot and rebound between the baffles. The dust is carried away so that it cannot rise or swirl above and obstruct the operators view. The dust-laden air passes through the floor gratings and enters a hopper which tapers to a horizontal screen placed just above the pressure tank. Nails, wires, gaggers and other foreign matter are caught on the screen in the hopper and readily removed. The sand after being cleaned collects in the hopper directly beneath the floor above the pressure tank. Every time the air pressure in the tank is removed the filling valve in the tank head opens automatically and the accumulated sand flows by gravity into the pressure tank. The control mechanism is entirely air operated giving any variation from a lean to a dense mixture of sand and air. Air valves are located inside the house at a convenient height from the floor. It is unnecessary to enter the pit to reach any control. However, space is allowed for a man to enter and remove wire and sprue that gather on the screen.

C. E. Tremmer, connected with the sales force of Rogers, Brown & Co. at Chicago, has been transferred to the St. Louis office, effective May 21. He formerly was attached to the St. Louis office.

Equipment Sales Slacken

Many Inquiries for Foundry Equipment Are Being Received but Are Not Turning into Orders as Rapidly as Expected—Firms Pleased with Results of Foundrymen's Convention

WHILE large live inquiries continue to be received by equipment manufacturers the volume of orders is not as great as it was recently. However, orders during May have kept up with production in most lines. Sand-handling and sand-blast equipment has been in strong demand. The W. W. Sly Mfg. Co., Cleveland, has sold sand-blast equipment to the National Malleable Castings Co., East St. Louis, Ill.; the C & G Cooper Co., Mt. Vernon, O.; and the Browning Co., Cleveland. This company also sold a large number of tumbling mills and dust arresters, including orders for 20 mills to the Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich.; 3 continuous tumbling mills to the Ford Motor Co., Detroit; 7 tumbling mills to the Dalton Foundries, Warsaw, Ind., and other orders in various parts of the country from Massachusetts to California. The Pangborn Corp., Hagerstown, Md., has sold a complete sand-blast equipment to Francis Keil & Son, Inc., New York, and to the Eriez Stove & Mfg. Co., Erie, Pa. The same firm has received an order for a sand-blast room equipment from the Union Steel Casting Co., Pittsburgh, and from the Lackawanna Foundry Co., Hazelton, Pa. Also orders for ventilating equipment have been received from the Benton Harbor Malleable Foundry Co., Benton Harbor, Mich., and from the Koehring Co., Milwaukee. Many inquiries are being received by oven manufacturers and some sales have been made. The Foundry Equipment Co., Cleveland, has closed on 6 ovens and complement of racks to the Belle City Malleable Iron Co., Racine, Wis., and has sold 2 ovens to the Plessisville Foundry, Ltd., Plessisville, Que., Canada. Activity in the molding machine field is above normal. A large molding machine manufacturer of Cleveland has sold four electrically operated rollover machines to the Westinghouse Air Brake Co., Wilmerding, Pa., and has received an order from the Penn Seaboard Co., for a second electrically operated rollover jolt machine of the pattern-draw type with a run-out car. During the Foundrymen's convention this company sold 29 molding machines of various types.

Uncertainty in Chicago Market

APPARENTLY the foundry industry in the Chicago district is a little uncertain of the future and as a result is slow to close for foundry equipment which is really needed. As a result of this manufacturers of foundry appliances find they have a heavy inquiry which does not close readily. This applies to ladles, trucks and small articles, as well as to tumbling barrels, cranes and molding machines. A similar lull was experienced a few weeks ago with a quick recovery and it is believed this experience will be repeated in the present instance. The Southern Wheel Co., St. Louis, has purchased a 54-inch cupola and the Central Foundry Co., Ft. Wayne, Ind., a 42-inch cupola from the Whiting Corp. Considerable interest is being manifested by foundries all over the country in the matter of sand preparation and the National Engineering Co. recently has shipped an unusual number of mixers. Among them are one each to Chalmers & Williams, Chicago Heights, Ill., the Kendallville Foundry Co., Kendallville, Ind., the Warman Steel Castings Co., Los Angeles, the Keystone Iron & Steel Co., Los Angeles, and the Montreal Motor Works, Montreal, Canada. In addition the company has made shipments of mixers, one each to Japan, New York and Pennsylvania, and two to Massachusetts. New foundries and additions or re-arrangement of existing plants are being planned and engineers and architects have a number of projects under consideration, which will come out later in the year. Present building cost and labor difficulties have a tendency to hold them back for the present.

Sales Disappointing But Inquiries Strong

SALES of foundry equipment during the past week or 10 days have been disappointing to the trade in the Pittsburgh area, as the many inquiries on hand are not turning into orders as rapidly as was expected. Inquiries still are current for various types of foundry equipment, and in molding machines particularly, represent widely divergent lines of casting production. For some reason a decided tendency has developed to hold back orders for the time being. In part this is traced to the increasing shortage of labor which is hampering various foundries in their operating schedules, molders being particularly scarce. As long as present equipment cannot be kept engaged, operators see no particular need for buying more. Molding machine inquiries are being received from every section of the country. Occasionally a repeat order is reported by the Herman Pneumatic Machine Co., such as the one for a large rollover machine received last week from the Flockhart Foundry Co., Newark, N. J. Four or five inquiries give promise of closing up early. One 1½-ton electric furnace recently was purchased from a Pittsburgh interest by a foundry operator. Also several ladle dryers for gray iron foundries were purchased. The J. M. Crawford Foundry Co., Pomeroy, O., may soon purchase equipment for a foundry addition, and D. J. Renaud & Son., 672 West End avenue, Carthage, N. Y., is planning the installation of additional equipment of various kinds. One or two inquiries still are current here for core ovens, cupolas, tumbling barrels, etc. Recent purchases of steel, pressed steel and iron flasks have been fairly numerous, mostly repeat orders from foundries engaged in special work. Hoists, cranes, etc., continue to engage the attention of some larger iron and steel foundry operators. The Reliance Steel Casting Co., Pittsburgh, is in the market for a 5-ton crane with 28½-foot span. The Bonney-Floyd Co., Columbus, O., purchased a 25-ton locomotive crane from the McMyler-Interstate Co., Bedford, O. The Lorain Steel Co., Johnstown, Pa., purchased a 20-ton crane from the Pawline & Harnischfeger Co., Milwaukee, while the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., ordered two 15-ton electric traveling cranes for South Philadelphia from the Milwaukee Electric Crane & Mfg. Co., Milwaukee. The Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., reports a fairly large number of single crane orders as well as specifications for groups of hoists, such as those received recently from the

Union Steel Casting Co., Pittsburgh, and the Columbus Malleable Iron Co., Columbus, O.

Few New Projects in East

ALTHOUGH few new projects are noted in the eastern district, demand for foundry equipment continues brisk. Sellers in many lines are booked well ahead. Sand cutters are offered at around 4 weeks delivery in the smaller sizes and as far ahead as 16 weeks in the larger. Sandblast machines are quoted around 4 or 5 weeks delivery, and while molding machines in some instances can be had out of stock, some sellers are sold several weeks in advance. Deliveries on electric overhead cranes range around 3 to 4 months, with few exceptions. In some of the lighter lines of conveying equipment, deliveries can be had in much shorter time. Prices generally are tending upward, particularly of conveying equipment.

The Hunts-Spiller Mfg. Co., Boston, has recently closed on a large order of powdered coal equipment to the Grindle Fuel Equipment Co., a subsidiary of the Whiting Corp. This is in addition to a large order for cranes and other miscellaneous equipment reported in a recent issue as placed by this company with the Whiting Corp. The Hudson River Foundry Co. is in the market for an overhead trolley system for its plant at Poughkeepsie, N. Y. The American Brass Co., Ansonia, Conn., has closed on a 4-ton monorail system to the Shepard Electric Crane & Hoist Co. A used overhead electric crane has recently been purchased by the Reading Iron Co., Reading, Pa. The Berlin Foundry & Machine Co., Berlin, N. H., has closed on a 5-ton electric overhead crane to the Whiting Corp., and the Philbrick-Booth Co., Hartford, Conn., has also closed on a similar sized crane to an unknown builder. The American Locomotive Co. is inquiring for a 15-ton and a 10-ton overhead crane for its Schenectady, N. Y., plant, and two single legged gantry cranes for its Chester, Pa., plant.

Property has recently been acquired in Philadelphia by the American Boiler & Foundries Co. for the erection of a plant. The Reading Foundry & Supply Co., Reading, Pa., will start work shortly rebuilding a portion of its plant recently badly damaged by fire. The loss was estimated at about $40,000. The Elmira Foundry Co., Elmira, N. Y., is expected in the market shortly for equipment for a new 1-story foundry, 115 x 125 feet.

What the Foundries Are Doing

Activities of the Gray Iron, Malleable, Steel and Brass Shops

The Paul Foundry Co., Waterloo, Iowa, is planning the erection of a plant building.

Erection of a foundry and machine shop is planned by the Studebaker Corp., South Bend, Ind.

Construction of an addition to its foundry building, 40 x 60 feet, has been started by the Holland Foundry Co., Holland, Mich.

The Wilson Foundry & Machine Co., Pontiac, Mich., plans the erection of an addition to its plant.

Erection of a 1-story foundry addition is being planned by the Regent Stove Co., Wyandotte, Mich.

Work has been started on the erection of an addition to the plant of the Palmyra Foundry, Palmyra, N. J.

The Buffalo Bronze & Die Casting Co., Buffalo, plans the erection of a 1-story plant building.

Property has been purchased at Philadelphia by the American Boiler & Foundries Co., on which it plans to erect a plant.

The plant of the Reading Foundry & Supply Co., Seventh street, Reading, Pa., recently was damaged by fire.

Erection of a foundry building, 60 x 150 feet, is being planned by the Cedar Falls Foundry Co., Inc., Cedar Falls, Iowa.

The plant of the Ellsworth Foundry & Machine Works, Ellsworth, Me., recently was damaged by fire.

Erection of an addition to its plant, 38 x 140 feet, is planned by the Quad Stove Co., Columbus, O.

The Pettibone Mulliken Co., 140 South Dearborn street, Chicago, is reported planning some alterations and improvements to its foundry building at an estimated cost of $20,000.

Erection of a 1-story foundry building, 115 x 220 feet, is being planned by the Elmira Foundry Co., Woodlawn avenue and Main street, Elmira, N. Y.

With a capital stock of $100,000, the Raleigh Stove Co., Raleigh, N. C., recently was incorporated by W. H. Johnson, F. O. Himer and F. P. Meir.

Fire recently damaged the plant of the Hill & Griffith Co., Cincinnati. This is the second plant of the company to be damaged by fire within a few weeks.

The Ross-Meehan Foundries, Chattanooga, Tenn., has purchased one of the plants of the Lucey Mfg. Corp., at a cost of $50,000. The plant has not been in use for some time.

Contract has been awarded by the Sibbitt Iron & Foundry Co., 217 Moore avenue, Wichita, Kans., for the erection of a 1-story addition to its plant.

The Oklahoma Steel Castings Co., Tulsa, Okla., plans the erection of an addition to its plant. E. H. Cornelius is president of the company.

Contract has been let to the Austin Co., Cleveland, by the American Foundry Co., Chicago, for the erection of a factory building to be built at an estimated cost of $100,000.

The Amory Street Foundry Co., Boston, has been organized by Bert Seabough and Arthur L. Guilfoyle, 380 Amory street, Jamaica Plain district.

Capitalized at $30,000 the Welsmech Co., Hattiesburg, Miss., recently was incorporated to engage in a general foundry business by S. E. Travis Jr., R. B. McGowen and others.

The Mississippi Foundry & Machine Co., Jackson, Miss., has let a contract for the erection of a plant building, 60 x 160 feet, to be built at an estimated cost of $25,000.

General foundry and machine shop business will be engaged in by the New Jersey Valve & Fittings Co., Hawthorne, N. J., which recently was incroporated with a capital stock of $200,000.

Capitalized at $50,000 the E. J. Bennett Castings Co., Cleveland, recently was incorporated by L. M. Sewell, S. E. Trackman, Gilbert Morgan, C. Mayer and E. C. Wolfe. Offices are in the Engineers building.

The Heating Range Mfg. Co., 4716 Fairmont avenue, Kansas City, Mo., plans the erection of a plant building, 100 x 150 feet, and will install foundry and machine shop equipment.

The Chicago Malleable Castings Co., 1249 West 120th street, has let a contract for the erection of a 1-story plant building, 50 x 150 feet, to be built at an estimated cost of $25,000.

The new foundry of the Campbell, Wyant & Cannon Foundry Co., Detroit, has been placed in operation with a production of 100 tons daily. It is planned to increase this production as the company has on hand a large contract for the Durant Motor Co.

The Jefferson Union Corp., Lexington, Mass., has been incorporated to make pipe fittings, etc., with $1,000,000 preferred stock and 10,000 shares of common stock, by Charles H. Stebbins, Cambridge, Mass., Arthur W. Freeman and Edward S. Crockett.

The Newark Malleable Iron Works, Newark, N. J., has completed a wing, 100 x 125 feet, on the end of its malleable iron foundry. The addition has been equipped with three sandblast barrels, a 15-ton furnace and other equipment. The addition doubles the melting capacity of the company.

The Taplin-Rice-Clerkin Co., Akron, O., following the recent fire at its North Akron, O., plant, expects to be back on a 100 per cent production basis within a few weeks. The company now is working on plans for the erection of a new foundry building to be completed soon. The new structure is expected to be 50 per cent larger than the one destroyed and will involve the expenditure of about $150,000.

For the purpose of manufacturing metal products, and polishing, plating and buffing them, the Excelsior Die Casting Co., 1812 Ellen street, Chicago, recently was incorporated with a capital stock of $10,000. The company has leased a building and is equipping it with complete die casting and plating equipment. It is expected the plant will be ready for operation early in June. Officers of the company are: President, I. Weinstein; vice president, F. J. Mass; treasurer, J. Strzelecki, and secretary, M. Arkuszewski. Messrs. Weinstein and Mass also are owners of the Excelsior Plating Works, Chicago.